NARROWING THE GAP

CORRELATING STREET WIDTH AND PEDESTRIAN SAFETY TO JUSTIFY NARROWING URBAN STREETS

by

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A REPORT

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Abstract

Many cities in the United States have developed into auto-dominated places with decreased accessibility for pedestrians and bleak cityscapes of wide, barrier-like streets. While many studies exist on the correlation between street width and vehicular safety, and vehicular speed and pedestrian safety, little information is available on the correlation between street width and pedestrian safety.

This project began while the researcher interned with the New York City Department of Transportation (NYCDOT) Pedestrian Projects Group (PPG). The researcher was asked to begin a study of New York City (NYC) streets, specifically analyzing the relationship between street width and pedestrian safety using NYC safety data. The street types studied represent a variety of conditions found in many cities. The exploratory correlation study, completed after returning to Kansas State University, found that narrow streets trend towards higher safety.

The correlation study between street width and pedestrian safety provides justification to narrow Bluemont Avenue in Manhattan, Kansas and increase pedestrian safety. Bluemont Avenue is a primary vehicular connection between the east and west sides of Manhattan. The city's future construction plans propose widening the street to accommodate a center turning lane along the entire length of Bluemont Avenue.

The research presented in this report supports the hypothesis that narrower streets are safer for pedestrians. By utilizing the results of the study, a designer can strengthen their argument to narrow wide, auto-dominated streets. In addition, the use of a two-stage design process can create a safer environment for pedestrians on Bluemont Avenue. By utilizing a temporary design followed by a permanent installation, the City of Manhattan can decrease the priority of Bluemont Avenue within the vehicle hierarchy and increase pedestrian safety. The intent of this report is to begin a conversation with the City of Manhattan to begin looking at streets not as mere vehicular paths, but paths for all modes of transit.

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INTRODUCTION

Dilemma

Many cities in the United States have developed into auto-dominated places with decreased accessibility for pedestrians and bleak cityscapes of wide, barrier-like streets (figure 1). While many studies exist on the correlation between street width and vehicular safety, and vehicular speed and pedestrian safety, little information is available on the correlation between street width and pedestrian safety.

Bluemont Avenue is a primary vehicular corridor between the east and west sides of Manhattan, Kansas. Classified as an urban arterial, Bluemont Avenue separates the northern and southern portions of the city.

Future plans call for the widening of the avenue to accommodate growth, which from a pedestrian point of view, will further isolate these two portions of the city. Manhattan is continuing the trend of prioritizing the car at the cost of the pedestrian. The dilemma faced by Manhattan, Kansas is how to accommodate growth and traffic while also meeting the needs of pedestrians.

Relevance

As the United States continues to widen the gap between vehicles and pedestrians, the health, safety and welfare of citizens declines. Wide, auto-dominated streets are a major barrier in the urban fabric and deter walkability in cities. Increasing safety along pedestrian-vehicular corridors encourages walkability. Wide, single modal streets with low pedestrian safety deter human interaction with the streetscape and hinder the development of vibrant communities. This exploratory

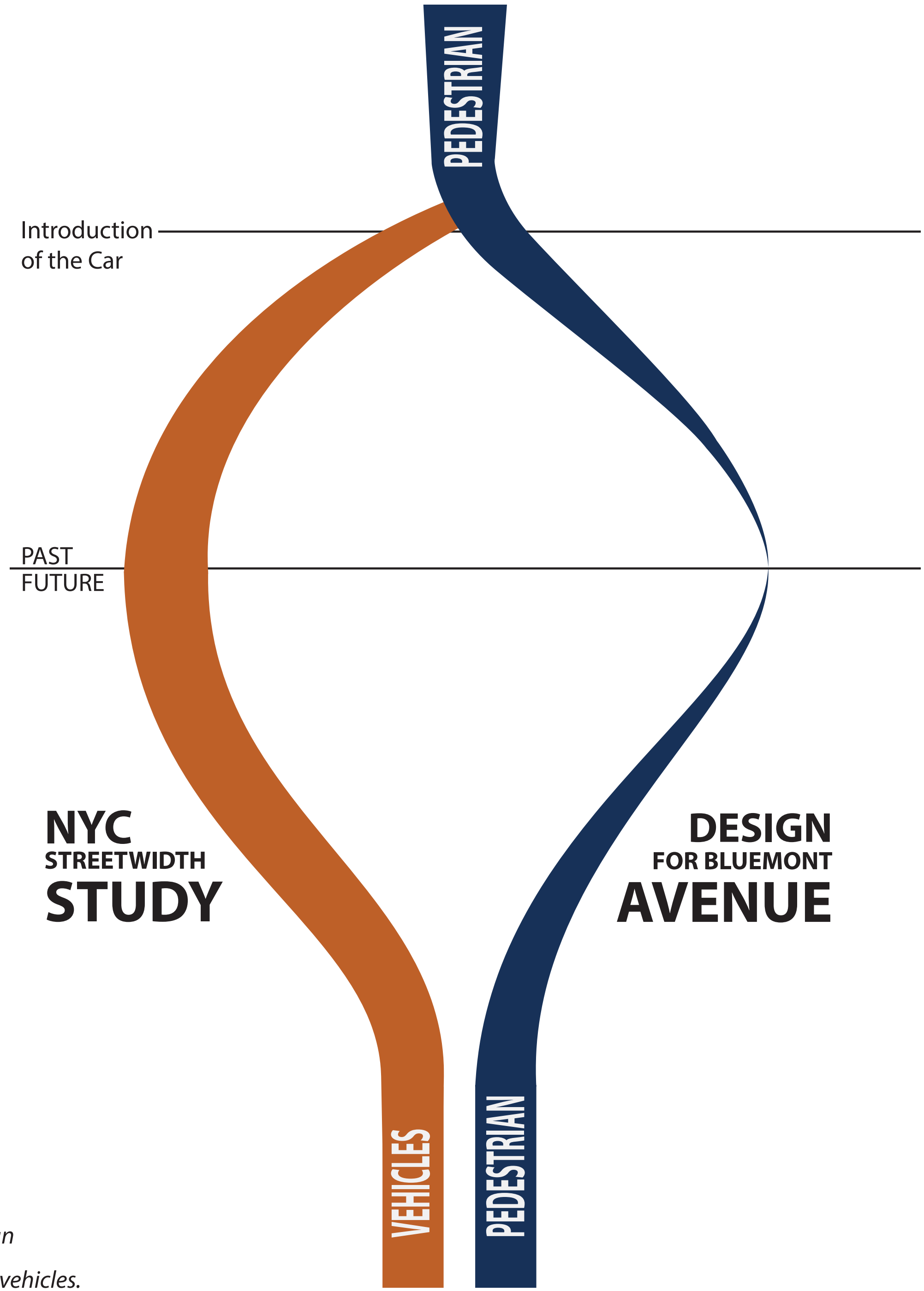


Fig. 1. **PROJECT CONCEPT DIAGRAM**

The NYC street width Study and Bluemont Avenue Design Intervention narrows the gap between pedestrians and vehicles.

study of the correlation between street width and pedestrian safety will provide a basis for further exploration by designers, planners, and engineers.

Thesis

The researcher hypothesizes that the correlation study between street width and pedestrian safety will reveal that narrower streets are safer for both pedestrians and other modes of transit. This exploratory study will assist in providing justification to redesign Bluemont Avenue in Manhattan, Kansas as a narrower street that reprioritizes the pedestrian and asks the city of Manhattan to begin looking at streets not as vehicular paths, but paths for all modes of transit.

Bluemont Avenue

Bluemont Avenue is a major vehicular corridor between the east and west sides of Manhattan, Kansas. Currently classified as an arterial, the design of Bluemont Avenue resembles a collector street due to its urban context. The avenue contains four moving lanes, two in each direction, except at primary intersections where widening to five lanes accommodates left turn lanes (figure 2).

As a primary entry street into the city, Bluemont Avenue functions as one of the gateways to the city. The avenue leads directly to Kansas State University. If the future widening plan is implemented, the character of Bluemont Avenue will be diminished and visitors' first impressions of Manhattan and the university will be a wide strip of asphalt from 4th Street to Manhattan Avenue.

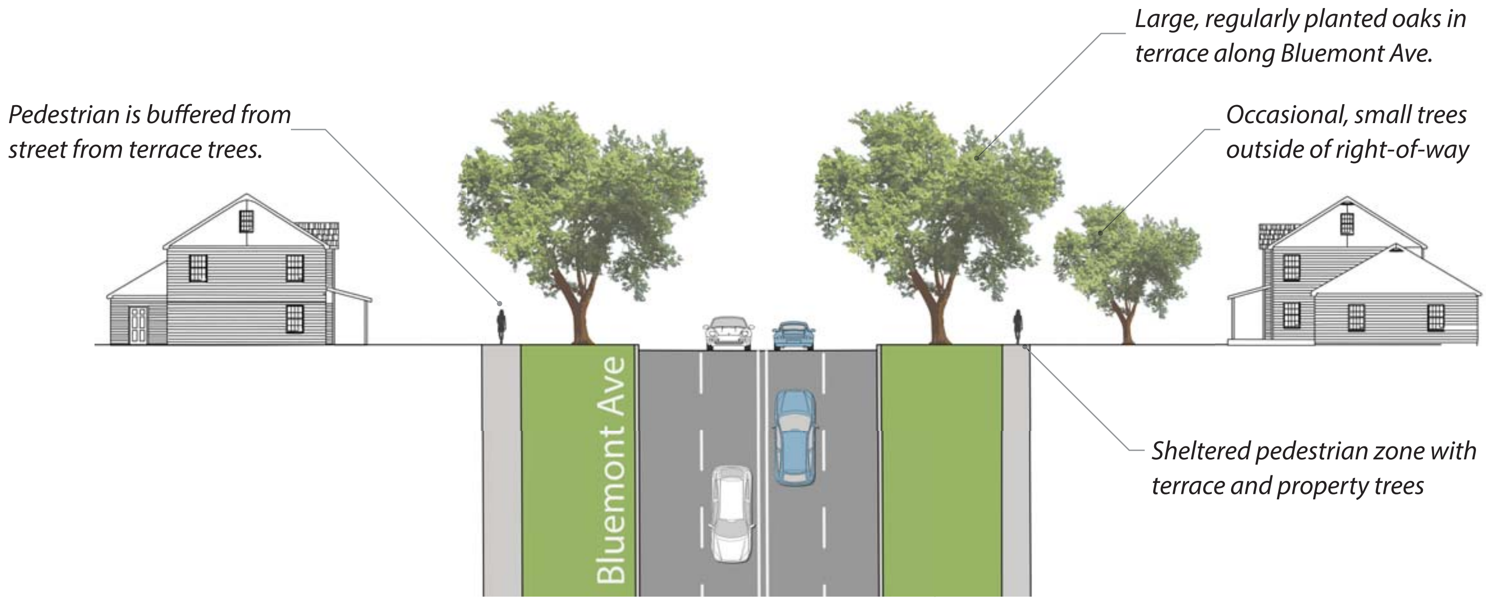


Fig. 2. **TYPICAL CONFIGURATION OF BLUEMONT**

Throughout this document, section view combined with lane configuration in plan view is used to illustrate street conditions. Existing typical configuration of Bluemont Avenue is four Lanes with left-turn lanes at major intersections.

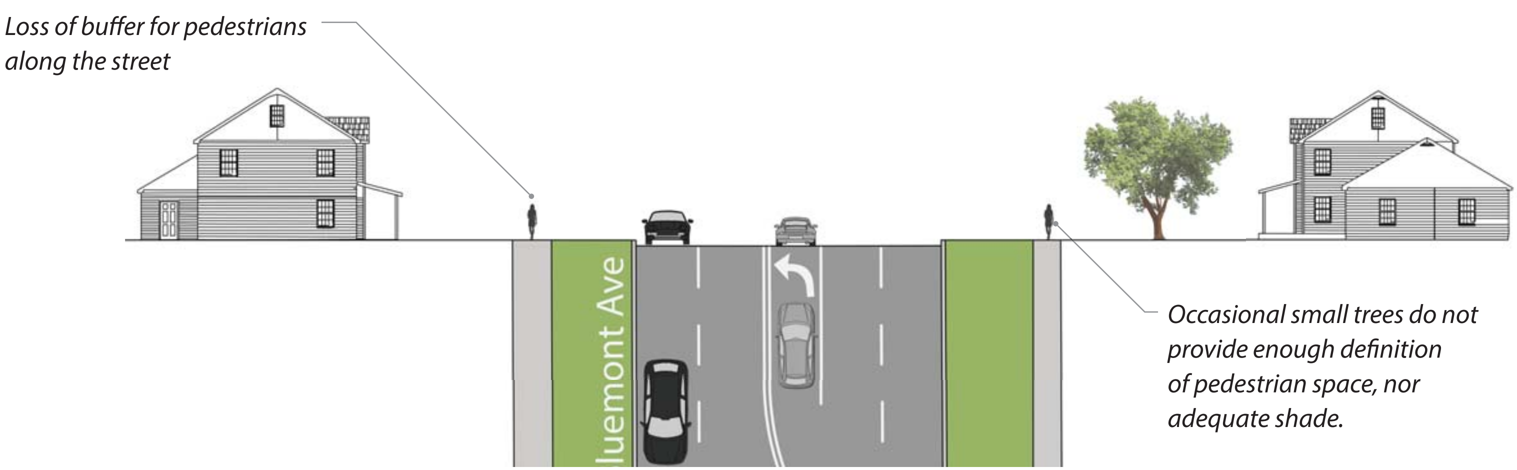


Fig. 3. **CITY'S PROPOSED CONFIGURATION OF BLUEMONT**

Proposed plan accommodates a left-turn lane along the entire length.

An existing positive quality of Bluemont Avenue is the presence mature trees that line the street and shade the single-family homes and low-rise apartment buildings. The primary existing problem with Bluemont Avenue is that residents living south of Bluemont Avenue are cut off from the available green space by the wide, barrier-like avenue. Located at the intersection of Bluemont Avenue and Juliette Street, where Bluemont Avenue is wider to accommodate left turn lanes, Bluemont Elementary playground functions as the neighborhood park for the surrounding residents. The playground is directly adjacent to the avenue.

Future Design Plans

Currently, the city of Manhattan is planning to widen Bluemont Avenue (figure 4) further to accommodate left turn lanes along the entire corridor. Widening the street will further increase the crossing distance for pedestrians and separate the two halves of the city. The city's proposed design will widen the avenue to resemble another major arterial in the city, Fort Riley Boulevard (figure 5). Fort Riley Boulevard is the primary arterial bordering the southern edge of the city.

Wide setbacks and lack of streets trees has created an inhospitable environment for pedestrians along large portions of Fort Riley Boulevard. If Bluemont Avenue is widened to resemble Fort Riley Boulevard, the character of a thriving, residential street will be destroyed and the two halves of Manhattan further separated.

Through studying the correlation between street width and pedestrian safety and developing design alternatives for Bluemont Avenue, this report can open a conversation with the City of Manhattan to begin looking at streets not only as vehicular paths, but paths for all modes of transit.

Fig. 4. **FORT RILEY BOULEVARD**
Long crossing distances and lack of pedestrian facilities.

Fig. 5. **BLUEMONT AVENUE**
Established street trees and pleasant, urban character.

BACKGROUND

WHERE WE'VE BEEN

History of Street Development

The early 1900's saw the development of the automobile as well as the beginning of the planning movement. Streets were multi-modal spaces that provided usable open space to city dwellers. As automobile usage grew after 1910, the speed and number of cars quickly overwhelmed other road users (Miles-Doan and Thompson 1999).

In addition to the growing automobile focus of society, the philosophies of Modernist Urban Design in the 1920's eroded the walkable city. Modernism favored separating usage as well as spreading buildings farther apart. Figures 6 and 7 depicts the difference between Modernist Urban Design and traditional design by comparing the modern New Dorp Beach, Staten Island community with the traditional West Village, New York neighborhood. Engineers ignored walking in favor of the car, which allowed farther, faster travel. The dissolution of the urban fabric also provided room for pedestrian free, high-speed road systems that created barriers to people on foot by breaking up the pedestrian network (Southworth 2005).

By developing around the car, the street lost its pedestrian scale and experience (figure 8). Streets became wide, bleak barriers to pedestrians. Concerned with safety, planners separated pedestrians and automobiles by casting pedestrians into dark underpasses or onto overhead skywalks, further removing them from the streetscape (Southworth 2005).

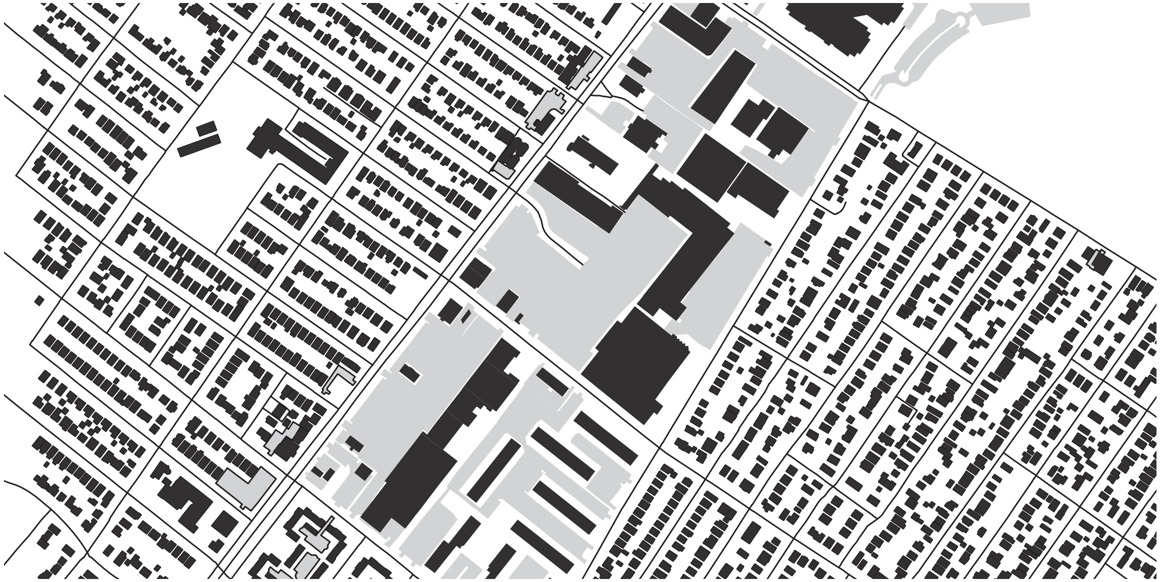


Fig. 6. **URBAN DEVELOPMENT**

New Dorp Beach, Staten Island devotes large quantities of land to parking lots and dissolves the urban fabric with spread out structures.

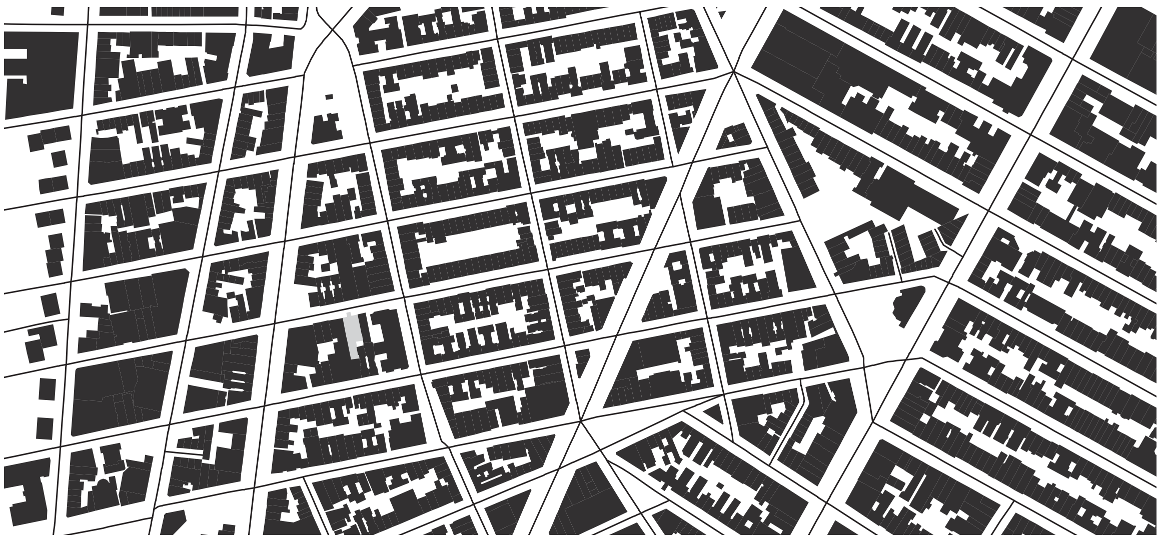


Fig. 7. **URBAN DEVELOPMENT**

The West Village in New York maintains traditional, dense development allowing for navigable streets for pedestrians.

Fig. 8. **LACK OF PEDESTRIAN FACILITIES**

Bus stop in the Bronx, New York lacks necessary pedestrian facilities creating unsafe conditions for all modes of transit. Used with permission from NYCDOT. 2014.

In response to the standard design principles for wide modernist streets, pedestrians have forsaken the street due to its decline into an unpleasant, unsafe environment. The question is now whether the technique of separation and seclusion has made any improvements in safety or if the reduction of pedestrian deaths simply displays a lack of walkability (Desyllas 2006).

Dominant Issues

"AS, VULNERABLE ROAD USERS, PEDESTRIANS ARE ALWAYS IGNORED DURING THE URBAN STREET DESIGN PROCESS AND HAVE A HIGH RATE OF DEATH IN TRAFFIC ACCIDENTS."

– SHI, YUAN, CHENG, AND HUANG. PEDESTRIAN SAFETY CONSIDERATION AND IMPROVEMENT. INTERNATIONAL CONFERENCE ON TRANSPORTATION ENGINEERING 2009.

Current design practices apply rural and suburban street design strategies to urban streets. The resulting designs lead to streets that accommodate speeding and pose a threat to pedestrians. Posted speed is determined by measuring the 85th percentile, normalizing speed not by how fast people should be going on a given street, but by how fast people can go. The resulting high-speed streets pose a threat to pedestrians and bicyclists (NACTO 2012).

Higher design speeds in urban settings lead to larger curb radii, wider lanes, no on-street parking, and large clear zones. This accommodation uses large amounts of valuable land as well as encouraging faster travel. The resulting built environment increases the risk of conflict between people traveling at different speeds (NACTO 2012).

Pedestrian safety is a national problem. 32,885 people were killed in traffic crashes in 2010. Traffic crashes are also the leading cause of death among children aged 5-14 (NACTO 2012). In addition, the death rate of children in cars, on the street, or on bicycles doubled between 1955 and 1990 (Desyllas 2006).

Looking to the Future

Walking and bicycling are key components of inter-modal communities. While attitudes toward walkability have improved, automobile transport expenditures exceed pedestrian and bicycle investments by 1,000:1 (Southworth 2005).

Streets are designed strictly for movement and efficiency, but instead should afford people with the opportunity to stop and interact. Reintegrating pedestrians into the design hierarchy and incorporating them into the design philosophy will develop lively streets (Desyllas 2006).

Benefits of a Multi-modal Society

Incorporating walkability into society provides many benefits. Walking is the core to the sustainable city: as a "green" mode of transportation, walking reduces noise, congestion and pollution while conserving energy. In addition to serving utilitarian uses, walking is used for social and recreational uses (Southworth 2005).

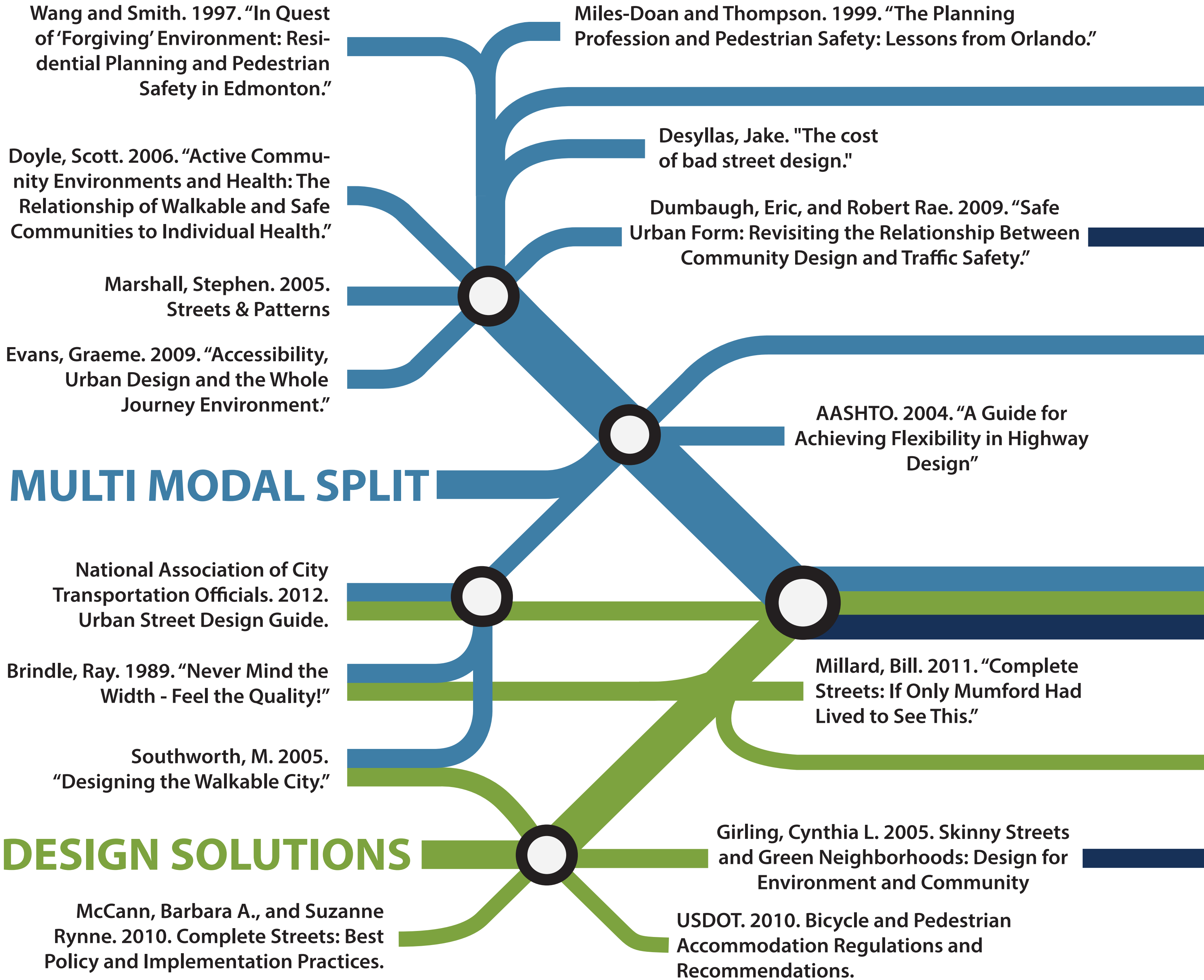
A 2003 study by Kevin M. Leyden analyzed the connection between pedestrian-oriented neighborhoods and levels of social engagement in Ireland. The study indicated that people who lived in walkable neighborhoods have higher levels of social capital than people living in car-oriented suburbs. Leyden concluded that walkable neighborhoods could encourage the development of social capital (Leyden 2003).

Walking is also readily available to all social classes. Walkable societies provide the poor, elderly, and children access to goods and services. These communities are under-served in auto dependent environments, as they are more dependent on alternative modes of transit (Southworth 2005).

Walkable communities also promote physical activity and health. A study conducted in 2006 analyzed the relationship between walking and the health of citizens. The study concluded that people who live in communities that promote exercise and activity are healthier and safer. The design of a neighborhood greatly affects the affordance of physical activity and walking, thus affecting health (Doyle 2006).

By forsaking the pedestrian in street design, designers and planners have created an unsafe environment for alternative modes of transportation. As we look to the future, designers and planners must create safe, multi-modal streets that encourage walkability and increase sustainability.

REVIEW



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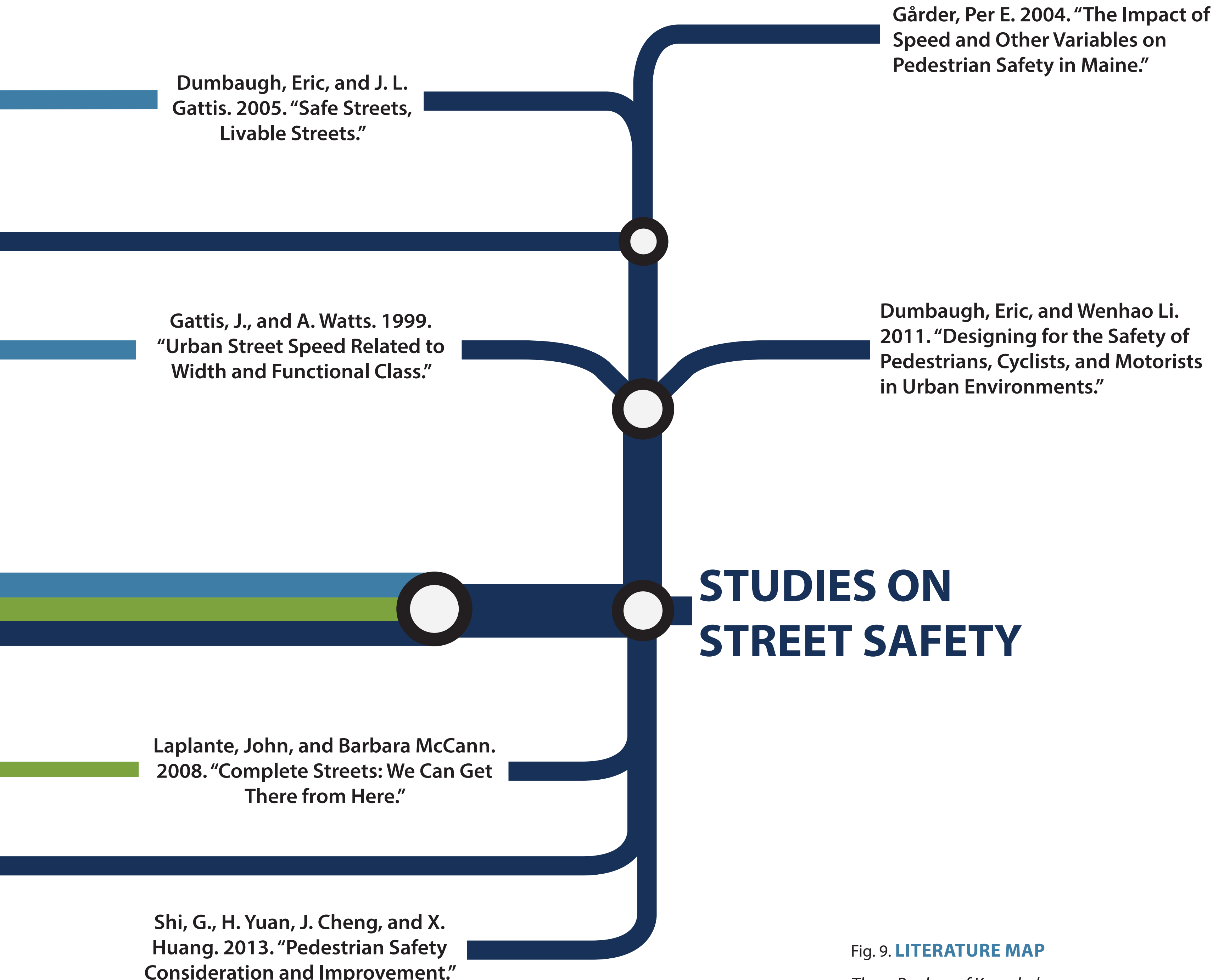


Fig. 9. **LITERATURE MAP**

Three Realms of Knowledge

THEORY OF STREET DESIGN

After the development of the automobile era, streets have been designed according to four primary design theories: Hierarchy (Marshall 2005), Street Grades (Miles-Doan and Thompson 1999), Speed and Efficiency (Dumbaugh and Rae 2009), and Prescriptive Design Standards (Brindle 1989). These design theories put emphasis on auto-dominated streets and have contributed to the decline of walkability.

Hierarchy

Many cities utilize a standard hierarchy design strategy. Streets are divided by function (Freeway, Arterial, Collector, and Local) and individual design standards for each typology are applied. Figure 10 displays the typical layout of the hierarchy system as well as the relationship between access and mobility (figure 11). Hierarchical design rarely addresses street context and applies broad design strategies. In the hierarchical design theory, pedestrians are looked at negatively as they slow down the flow of vehicles at intersections (Southworth 2005). A problem with this classification is that the pedestrian is generally isolated to the lowest rung of the traffic hierarchy (Marshall 2005).

A major problem of hierarchical design is the shortcomings of arterial streets and roadways. While local property access is prohibited on freeways, it has become commonplace on arterials. The design of arterial roads works to carry traffic with minimal conflict between property egress and cross streets. The use of these

Fig. 10. **HIERARCHY**

Typical configuration of street hierarchy.

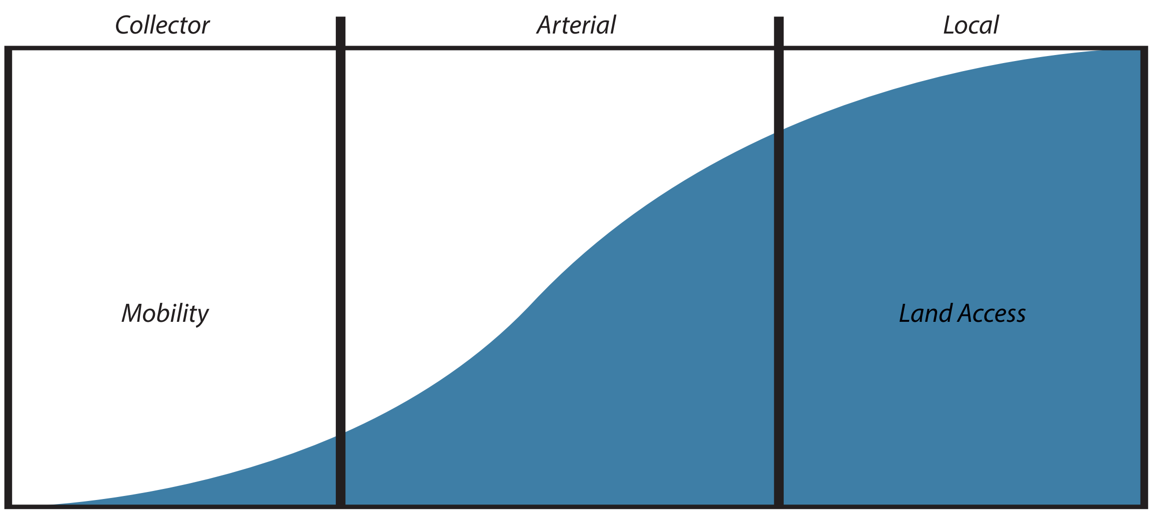


Fig. 11. **ACCESS**

Relationship between mobility and access. Adapted from Laplante and McCann 2008. Pg. 24.

streets by large volumes of commuters creates highly sought after properties along the corridors. The result is large high volume streets with large pedestrian generators and little to no pedestrian planning (Miles-Doan and Thompson 1999).

Levels of Service

Similar to hierarchical design, transportation engineers assign grades to streets based on capacity and speed. Grades "A" through "F" are given depending on how drivers would hypothetically perceive the driving quality of a proposed street design. Grade "A" is given to roads without impediments, restrictive speeds, or tight curves. Grade "F" is given to streets with many signals, long crossing times, slower speeds, and congestion. The street grade equation does not consider the needs of pedestrians and bicyclists (Miles-Doan and Thompson 1999).

Because there are no pedestrian grades included in street design, political leaders and engineers may operate as though they are unaware that the higher the grade for vehicles, the lower the grade for other modes of transit (Miles-Doan and Thompson 1999).

Speed

The geometry of a street is designed based on the selection of a street's design speed. The resulting street has wider lanes and clear zones, longer sight distances, and other high-speed elements. The design of arterial roadways assumes that straightening geometry and widening lanes reduces crashes by lengthening sight distances. This assumption, while appropriate in the early 1900's when vehicle speeds were relatively low, now allows vehicles to travel at higher speeds. The increased speed offsets any benefits to safety associated with sight distances (Dumbaugh and Rae 2009).

By using wide lanes and long sight distances, America is designing for the worst-case scenario. While these criteria may increase safety during heavy traffic flow, the remaining time the street is over-designed. Wide, empty roads with no on-street parking and long sight distances encourage people to drive faster, reducing safety (Gattis and Watts 1999).

"IT IS A MARK OF THE CRUDENESS OF OUR SYSTEM THAT SHODDY PROPOSALS WILL OFTEN BE REJECTED NOT BECAUSE THEY ARE POORLY DESIGNED, BUT BECAUSE THEY DO NOT COMPLY WITH... ARBITRARY (TECHNICAL) CONTROLS WHICH HAVE NO RELEVANCE WHATSOEVER TO REAL DESIGN. WHAT IS PROBABLY WORSE IS THAT MANY 'SHODDY PROPOSALS' ARE ACCEPTED BECAUSE THEY DO MEET THESE SAME ARBITRARY TECHNICAL REQUIREMENTS; THE SYSTEM EITHER HAS NO PROVISION FOR PUTTING THESE UNDER CLOSER SCRUTINY, OR (MORE LIKELY) IS SIMPLY UNABLE TO DETECT THEM."

- BRINDLE, RAY. 1989. "NEVER MIND THE WIDTH - FEEL THE QUALITY!" AUSTRALIAN PLANNER: JOURNAL OF THE ROYAL AUSTRALIAN PLANNING INSTITUTE 27 (O.4): 19–28.

Prescriptive Design Standards

Instead of using context sensitive design standards, transportation engineering has opted for prescriptive design standards that utilize codes, formal standards, and computer techniques. This rigid design strategy becomes little more than an exercise in getting the dimensions correct and leaves little room for creative design strategies (Brindle 1989).

Prescriptive design standards discourage varying from the norm and distract designers from creating context sensitive design solutions. In some cases, strict adherence may be an illusory tool to mask incompetent design. The unquestioning use of prescriptive design standards is described as a ‘cop out’ (Brindle 1989).

Due to limited data on walking, it is difficult to identify the real risk faced when walking. Advocates for safety argue that safety gains suggested by using the four theories are misleading. Street design may have led to less mobility, not increased safety (Desyllas 2006).

Within the past ten year, major transportation authorities have begun to realize the need to accommodate the pedestrians and other modes of transit. In 2004, the American Association of State Highway and Transportation Officials (AASHTO) published A Guide for Achieving Flexibility in Highway Design. In 2010, the United States Department of Transportation (USDOT) published Bicycle and Pedestrian Accommodations, Regulations and Recommendations. While great strides have been made by the AASHTO and the USDOT, continued research and proactive designs are needed to increase the priority of the pedestrians.

STUDIES ON STREET SAFETY

Research conducted on the topic of streets and pedestrian safety primarily fall within four categories: narrower equals safer (Dumbaugh and Gattis 2005), speed over safety (Dumbaugh and Li 2011), volumes (Gårder 2004), and design matters (Dumbaugh and Gattis 2005). These four categories analyze the relationship between pedestrians, vehicles, and the built environment.

Narrower=Safer

Street design standards specify that wider lanes create safer driving conditions. A study conducted in 1999 re-evaluated literature on street safety and found that there was minimal evidence supporting the idea that widening lanes beyond 11 feet enhanced safety. The study found that safety benefits stop upon reaching 11 feet and that crashes increased upon reaching and exceeding the 12 foot standard (Dumbaugh and Gattis 2005).

Another study in 2005 found that there was a high correlation between street width and accidents. In the study, 36-foot wide streets had 1.21 collisions per year while 24-foot wide streets had only .32 collisions per year (Girling 2005).

Speed over Safety

High-design speeds are desirable in order to promote motorist safety. However higher speeds are detrimental to pedestrians and bicyclists. Higher design speeds encourage higher driving speeds, which increase both the frequency and severity of crashes involving pedestrians (Dumbaugh and Li 2011).

When a vehicular accident involves a pedestrian, speed plays an important role. Shown in figure 10, an accident where the car is traveling at 20 miles per hour (mph), the pedestrian has an 85 percent survivability rate (figure 12). If the same car had been traveling 40 mph, the survivability rate would drop to just 15 percent (Laplante and McCann 2008).

Volumes

Sites with heavy use and high vehicular and pedestrian flows are expected to be associated with more crashes. Gårder conducted a study in Maine in 2004 analyzing the relationship between traffic volumes and crashes. The study concluded that locations with higher speed and wide roadways may also have more crashes that other locations with similar volumes (Gårder 2004).

Another assumption is that crash numbers are proportional to traffic volumes. In theory, if there are two identical streets and one street has twice the number of pedestrians, that street would have double the number of crashes. The Gårder study found that if there are more pedestrians, drivers will be more alert and will be ready to react and avoid a collision. In addition, in places with high vehicular volumes, pedestrians will be more careful when crossing the street (Gårder 2004).

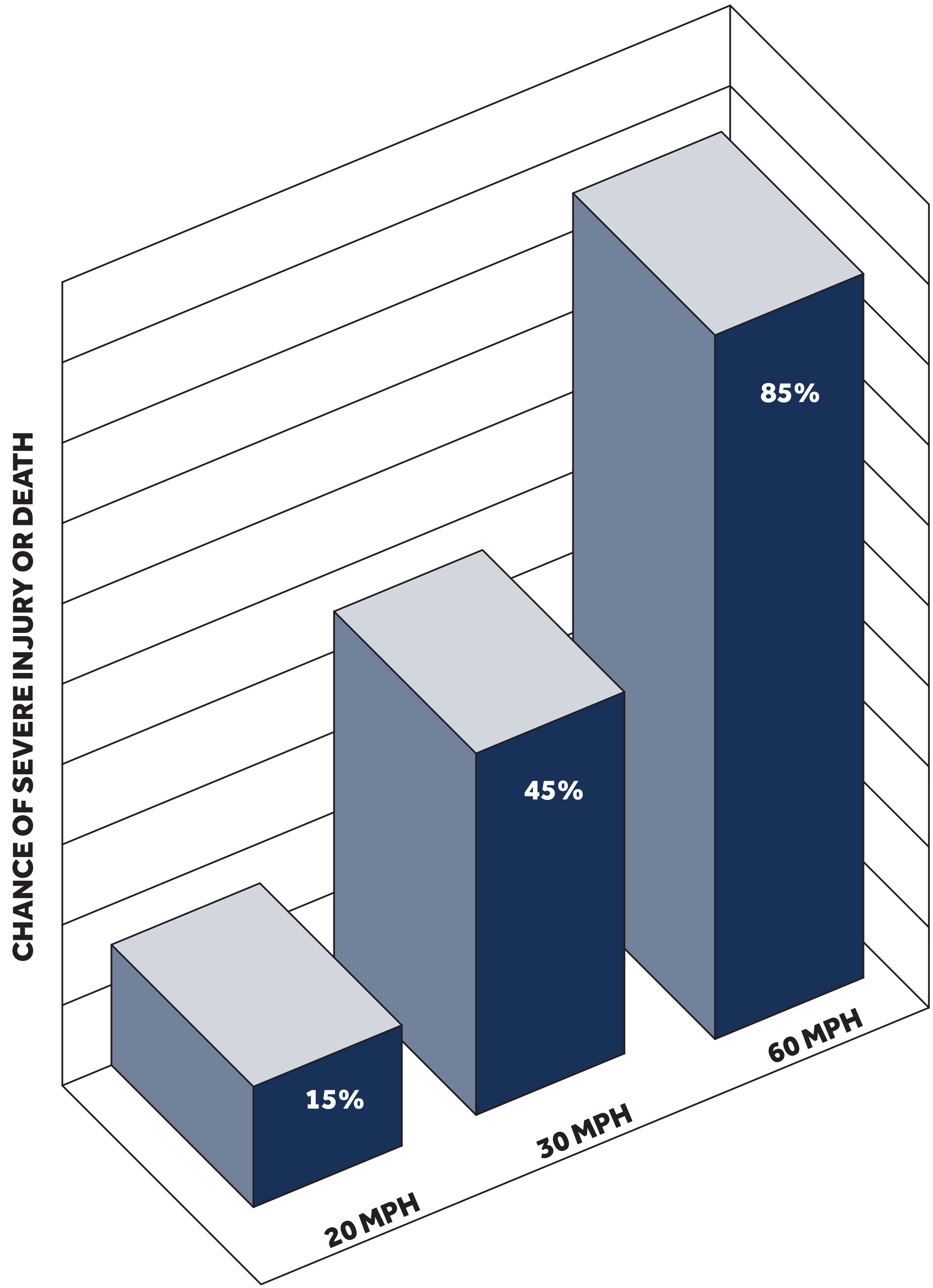


Fig. 12. **SPEED AND SURVIVABILITY**

Relationship between vehicle speed and pedestrian survivability in a collision. Adapted from Laplante and McCann 2008. Pg. 26.

Eric Dumbaugh and Wenhao Li conducted a study in 2011 to analyze the correlation between crash incidence and the built environment. The study found that traffic volumes have a minor effect on the number of urban traffic collisions when they are compared with patterns found in the built environment (Dumbaugh and Li 2011).

Design Matters

In 2001, P.J. Ossenbruggen conducted a study that examined streets in New Hampshire with urban, suburban, and residential street characteristics. The study hypothesized that the urban areas would be associated with higher crashes due to higher volumes. Instead, the study found that the urban areas with on street parking and pedestrian friendly street treatments were two times less likely to experience a crash. The study concluded that there is a correlation between the roadside environment and street safety (Dumbaugh and Gattis 2005).

Design choices also influence a driver's decision-making process based on risk homeostasis theory. The theory states that people make decisions on whether to participate in an activity by weighing the relative action against its perceived risks. Risk homeostasis theory postulates that while all activities have risks, people will adjust their behavior to maintain a low level of exposure to a perceived hazard. In regards to transportation, drivers will balance the benefits of higher speed against their individual perceptions of how hazardous the street is. When livable streetscape designs are incorporated, risk homeostasis theory predicts that drivers will compensate by adjusting their behavior and slowing down (Dumbaugh and Gattis 2005).

The theory also states that there is a difference between safety (empirical measure of crash performance) and security (individual perception of safety). The presence of wide lanes and large clear zones appear to reduce a driver's perception of risk, giving them a false sense of security. The implementation of livable streetscapes balances driver's security with the real risk of the environment. This allows drivers to be better prepared when a potentially hazardous encounter occurs (Dumbaugh and Gattis 2005).

Studies conducted on lane widths, travel speed, traffic volume, and street design have identified the problem between vehicular and pedestrian conflicts on streets. Research reveals that narrower lanes and slower traffic speeds reduce the number of collisions on streets (Dumbaugh and Gattis 2005). In addition, studies have shown that traffic volume may not be an accurate way to measure accidents (Gårder 2004). The relationship between conflicts and volume may not be linear (Gårder 2004). The design of streets plays a key role in increasing safety and changing the perceptions of drivers to modify hazardous behavior (Dumbaugh and Gattis 2005).

DESIGN STRATEGIES

In order to increase the safety of pedestrians on streets, the focus of designers needs to shift from purely function, to a balance of form and function. It is up to the designer to balance the design of function, safety, speed, and walkability. By using temporary strategies and the Complete Streets Methods, streets can be returned to the pedestrian.

Design for Function

The design of a street must allow the movement of traffic. However, the street needs to be designed in way that the priority is unambiguous. The role of the street in the larger transportation network must be established and the street should not cater to one mode of transit. If priority is unclear, vehicular traffic will claim unreasonable priority. The street must also provide for parking. Both location and quantity of parking must be present in order to protect visual quality and safety (Brindle 1989).

Design for Safety

A key principle to designing safe streets is designing for predictability. Motorist and pedestrians must be able to see each other and predict what they will do next. Unclear designation of crossing areas and unclear delineation of pedestrian and vehicular zones lead to confusion and collisions. The roadway must have the characteristics that produce safe environments (Brindle 1989).

In addition to being safe, streets must feel safe. Safety measures in place need to have high visibility to ensure both pedestrians and motorist feels safe when crossing and maneuvering. This is exceptionally important for parents of children in order to encourage walkability (Brindle 1989).

Design for Reasonable Speed

Street design should focus around target speed, or the speed at which the designer thinks traffic should go. General streets should range between 15-30 mph while alleys and shared spaces should be as low as 10 mph. The use of narrow lanes, trees, parking, and small curb radii, can reduce speed and encourage driving at the target speed. 10-foot wide lanes are sufficient when traveling at speeds less than 40 mph. On streets with large vehicles, 11-foot wide lanes are appropriate (NACTO 2012).

Design for Walkability

A walkable community provides access to everyday places where people are and want to go. Paths must be safe and comfortable and provide for varied ages and degrees of mobility. The network must link seamlessly and should not contain any hazards or interruptions. Walkable streets provide not only for utilitarian use, but also for social, recreation, and pleasure uses. Southworth identifies five key attributes on page 249 in *Designing for the Walkable City*:

- Connectivity of path network, both locally and in the large urban setting
- Linkage with other modes: bus, streetcar, subway, train
- Fine grained and varied land use patterns, especially for local serving uses
- Safety, both from traffic and social crime
- Quality of path, including width, paving, landscaping, signing, and lighting

Complete Streets

Bicycle advocates originally developed the Complete Streets Movement to improve bicycle infrastructure. Today, however, the movement has spread much farther than the realm of biking. The central idea of Complete Streets is to think of street right-of-ways as spaces for all users. This includes pedestrians, cyclists, seniors, children, and mass transit, not just motorists (figure 13). The street must be optimized to facilitate the multiple functions that occur with multi-modal transit (Millard 2011).

McCann and Rynne list the following 11 Complete Streets Guidelines on page 24 in *Complete Streets: Best Policy and Implementation Practices*:

- Specifies that "all users" includes pedestrians, bicyclists, and transit passengers of all ages and abilities, as well as automobile drivers and transit-vehicle operators.
- Encourages street connectivity and aims to create a comprehensive, integrated, connected network for all modes.
- Applies to both new and retrofit projects, including design, planning, maintenance, and operations, for the entire right-of-way.
- Directs the use of the latest and best design standards while recognizing the need for flexibility in balancing user needs.
- Directs that complete streets solutions will complement the context of the community.
- A true complete streets policy does not simply call for the addition of bicycle and pedestrian facilities but rather inspires a careful consideration of the needs of all travelers.

Fig. 13. **BROADWAY, NY TEMPORARY ENHANCEMENTS**

Use of paint to narrow roadbed and reclaim pedestrian space from vehicular space. Used with permission from NYCDOT. 2014.

Temporary Strategies

One of the focuses of Complete Streets is to create a large, interconnected network of streets through policy and institutional change (Laplante and McCann 2008). A missing component is the direct application to individual streets. The temporary strategies used by National Association of City Transportation Officials (NACTO) and the New York City Department of Transportation (NYCDOT) fill the gap between policy and permanent installation (figure 14).

By implementing projects quickly through temporary materials, cities are utilizing a stepped approach to major redesigns. Public decision can be informed in the process and the design can be changed easily and inexpensively if problems arise. Once the design is tested, it is replaced with permanent materials and designers have the understanding that the design is functional (NACTO 2012).

Conclusion

Throughout the development of cities in the United States, cars have taken priority and have left pedestrians in an unsafe environment. By strictly adhering to prescriptive design principles and common design theory, streets have widened and dissolved the pedestrian based grid network. The Complete Streets Method and temporary design strategies used by NACTO and NYCDOT can guide the redesign of streets to encourage walkability and provide safety for pedestrians.

Fig. 14. **TEMPORARY PLAZA ENHANCEMENTS**
Converting Road Space to Plaza Space. Used with permission from NYCDOT. 2014.

PROCESS

METHODOLOGY

The street width and pedestrian safety study consists of two parts, a study of New York City (NYC) streets and a proposal to redesign Bluemont Avenue in Manhattan, Kansas. Results from the NYC street width study provides justification for the redesign of Bluemont Avenue. The street width study analyzes the correlation between street width and pedestrian safety while the redesign of Bluemont Avenue is a direct application of street narrowing techniques.

Street Width Study

"WHAT IS THE CORRELATION BETWEEN STREET WIDTH AND PEDESTRIAN SAFETY?"

An exploratory study of New York City's streets, specifically analyzing the relationship between street width and pedestrian safety, reveals a correlation. In order to represent conditions found in many cities, a variety of street types were analyzed.

Data Collection

Safety data from 2007-2011 was used to conduct the study. Although volume data is typically used to study safety, volume data was not available for NYC streets. Streets were isolated by width and number of travel lanes within ARCGIS. Street segment identification numbers were collected and processed through the New York City Crash Database. Statistics from the database were placed in a table similar to table 1. The complete results from the street study can be found in Appendix B.

Table 1. **RAW DATA TABLE**

Raw data table calculates statistics extrapolated along one mile. The researcher then calculated averages, standard deviation, and confidence intervals.

Data Source: NYCDOT Database, Injury data: NYSDOT/NYSDMV Accident Database, Fatality data: NYCDOT/NYPD Reconciled Fatality Database. 2007-2011.

Street	From	To	Boro	Width (ft)	Route Length (Miles)	Number of Intersections	Intersections Per Mile	KSI	KSI Per Mile	Ped Injury
Stillwell Ave	Gunther Ave	Ely Ave	BX	38	0.4	8.0	20.0	0.0	0.0	0.0
Wickham Ave	E 222nd St	Burke Ave	BX	38	0.3	5.0	16.7	1.0	3.3	1.0
Clarkson Ave	Bedford Ave	New York Ave	BK	38	0.5	4.0	8.0	5.0	10.0	37.0
Hazen St	Astoria Blvd	20th Ave	QN	38	0.4	8.0	20.0	0.0	0.0	0.0
Hegeman Ave	Fountain Ave	Bradford St	BK	38	0.9	20.0	22.2	10.0	11.1	23.0
E 108th St	Flatlands Ave	Seaview Ave	BK	38	0.9	17.0	18.9	2.0	2.2	8.0
Foster Ave	McDonald Ave	Coney Island Ave	BK	38	0.6	11.0	18.3	5.0	8.3	27.0
Gates Ave	Broadway	Throop Ave	BK	38	1.0	8.0	8.0	12.0	12.0	60.0
7th Ave	Park Pl	Carroll Ave	BK	38	0.4	8.0	20.0	1.0	2.5	18.0
McClean Ave	Thompkins Ave	Mallory Ave	SI	38	0.9	20.0	22.2	2.0	2.2	6.0

	KSI	KSI Per Mile	Ped Injury	Ped Injuries Per Mile	Bike Injury	Bike Injuries Per Mile	Motor Injury
Average	3.5	5.1	15.5	23.6	4.4	6.8	67.0
Alpha	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Standard Deviation	3.9	4.4	18.6	25.9	5.9	9.1	56.5
Sample Size	12.0	7.1	12.0	7.1	12.0	7.1	12.0
90% Confidence Interval	± 1.9	± 2.7	±8.8	±16.1	± 2.8	±5.7	±26.8
Upper Limit	5.4	7.9	24.3	39.7	7.2	12.5	93.8
Mean	3.5	5.1	15.5	23.6	4.4	6.8	67.0
Lower Limit	1.6	2.4	6.7	7.5	1.6	1.2	40.2

KSI- Killed or severely Injured -Injury causing permanent damage or affecting day to day activities such as hospitalization, leave from work, or decreased mobility (NYCDOT).

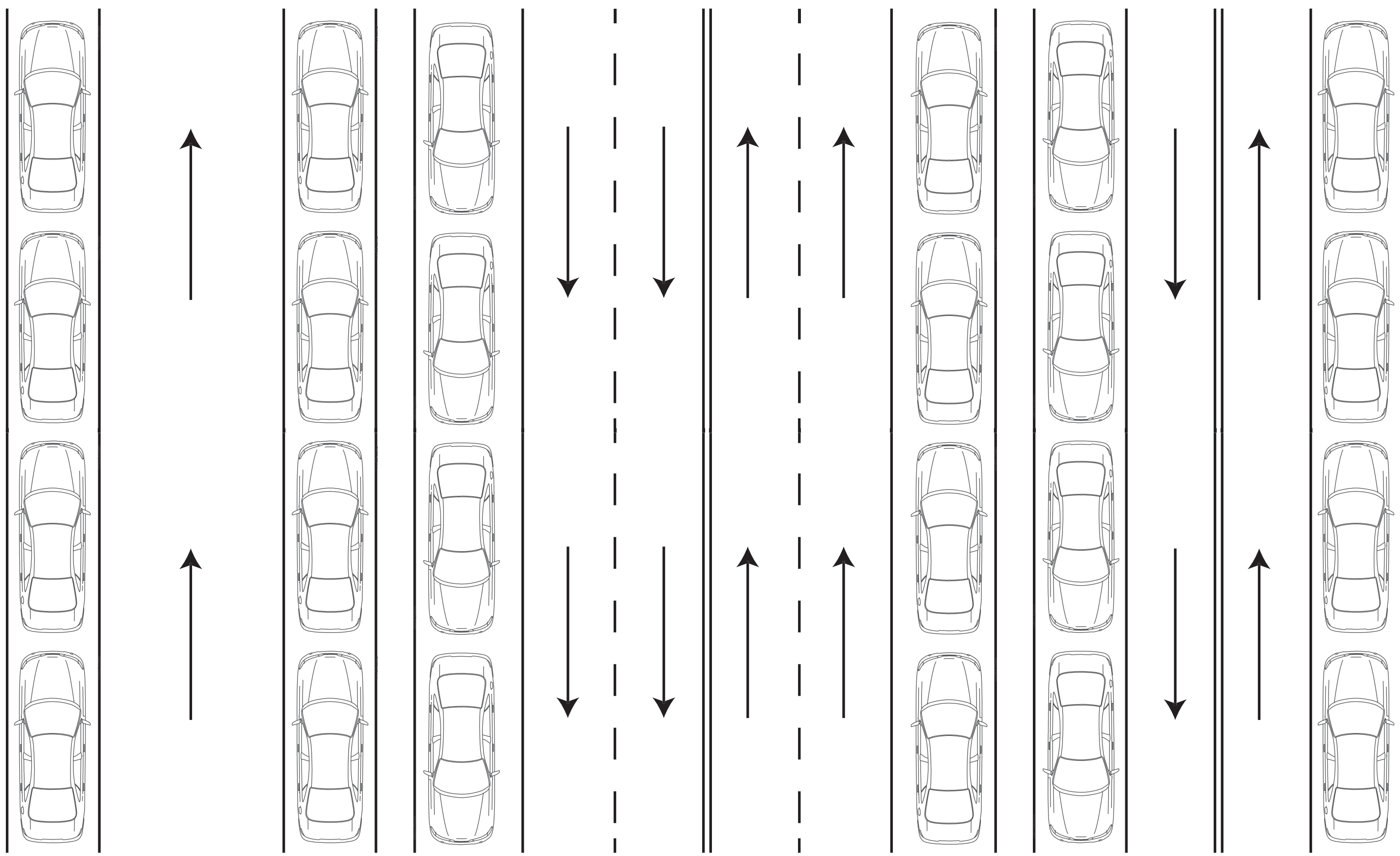
Control Variables

Three control variables were developed to limit variance in the study. Mary Wade, planner at NYCDOT, assisted with the development of the control variables.

- Street Type – Streets with the same number of lanes, travel directions and parking conditions constitute a single street type. The three street types studies are depicted in figure 15.
- Land Use – The primary variable to control pedestrian and vehicular volumes was surrounding land use (volume data was not available). Two categories of land use were applied: low density residential (single-family homes and low-rise residential) and mid-rise residential and commercial uses (Wade, 2013).
- Intersections – As many pedestrian conflicts occur at intersections, maintaining a consistent number of intersections per mile controlled variance in the results (Wade, 2013).

Fig. 15. **STREET TYPOLOGIES**

Four Street Types to be studied representing streets found throughout the country.



One Way, Two Parking Lanes

Two-Way, Four Travel Lanes, Two in Each Direction, Two Parking Lanes

Two-Way, Two Travel Lanes, Two Parking Lanes

Data Analysis

Collected data from the street width study was analyzed by calculating both the average number of injuries within a street type as well as the average number of injuries per mile. As the length of street segments studied differed sample to sample, the injury data was extrapolated along a mile of street to reduce variance in the data.

Five categories of statistics were included in the study: killed or severely injured (KSI), pedestrian injuries, bicyclist injuries, motorist injuries, and total injuries. Fatalities were not included in the final analysis as no correlation could be found in any of the street types studies.

A summary table (table 2) for each street type calculated the averages as well as revealing which street type was more dangerous by applying a color gradient. In addition to averages, a 90% confidence interval was calculated (figure 16). A confidence interval is a range of values, plus or minus the mean of the samples, that predicts the limits of where a new value added to the sample would fall.

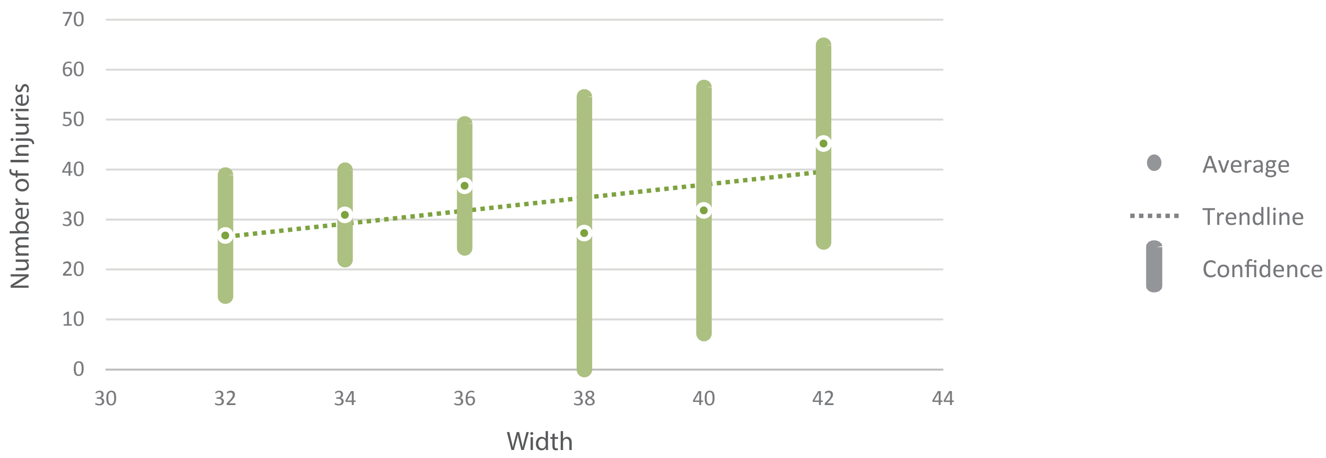


Fig. 16. **CONFIDENCE CHART**

90% Confidence Interval.

Two-Way Streets (One lane each direction) with Parallel Parking on both sides in Mid-Rise Residential and Commercial Areas																
Sample Size	**Width**	**Miles**	**Avg. # of Inter.**	**Inter. per mile**	**Avg. KSI**	**Avg. KSI /mile**	**Avg. Ped Injury**	**Avg. Ped Injuries Per Mile**	**Avg. Bike Injury**	**Avg. Bike Injuries Per Mile**	**Avg. Motor Injury**	**Avg. Motor Injuries Per Mile**	**Avg. Total Injuries**	**Avg. Injuries Per Mile**	**Avg. Fatalities**	**Fatalities Per Mile**
7	**32**	4.1	11.1	19.2	10.3	18.8	16.9	26.8	9.4	12.9	64.6	90.4	90.9	130.0	1.0	1.1
7	**34**	4.1	10.6	20.1	6.4	10.6	18.9	30.9	8.4	14.5	72.3	128.2	99.6	173.6	0.4	0.8
7	**36**	4.1	10.7	19.3	5.6	10.3	22.9	36.7	7.3	12.3	52.7	95.3	82.9	144.4	0.0	0.0
7	**38**	3.9	12.8	18.9	5.5	8.0	14.8	27.3	6.5	13.8	70.2	111.0	91.5	152.0	0.2	0.3
6	**40**	4.1	13.0	19.0	7.7	11.4	21.3	31.8	9.0	13.6	59.0	96.3	89.3	141.7	0.7	1.0
6	**42**	4.1	8.7	12.7	11.7	15.3	33.2	45.2	14.3	18.1	108.8	147.6	156.8	211.3	0.3	0.5
40 Streets																

Less Safe — *Safer*

Table 2. **AVERAGES TABLE**

Calculates averages for each category of street width. Color gradient denotes safety level.

STUDY

TRENDS TOWARDS NARROWER

Final analysis revealed an upward trend correlating higher injuries with wider streets in 92% of the statistics analyzed. In addition, 28% of the statics were statistically significant based at a 90% confidence level. Table 3 on the following page displays the results of the study. All summary tables and confidence charts are located in Appendix B.

The results were divided into two categories, trends and confidence. An analyzed statistic had an upward trend when a higher number of injuries were associated with wider streets. A linear trendline was used. Confidence in the calculated averages was determined by using a 90% confidence interval. Figure 17 demonstrates an upward trend as well as confidence in the averages between two street types.

There are two ways to analyze the data further. The first is to look at trends within the breakdown of street types. This is completed by analyzing the number of injuries for each street type (horizontal analysis of table X on the previous page). In three of the street types studied, all five categories of injuries had an upward trend that narrower streets are safer. The remaining two street types had upward trends in four out of five injury categories. The highest level of confidence occurred in two-way streets in mid-rise, commercial areas. This category of street had a 90% confidence level in four of the five injury categories.

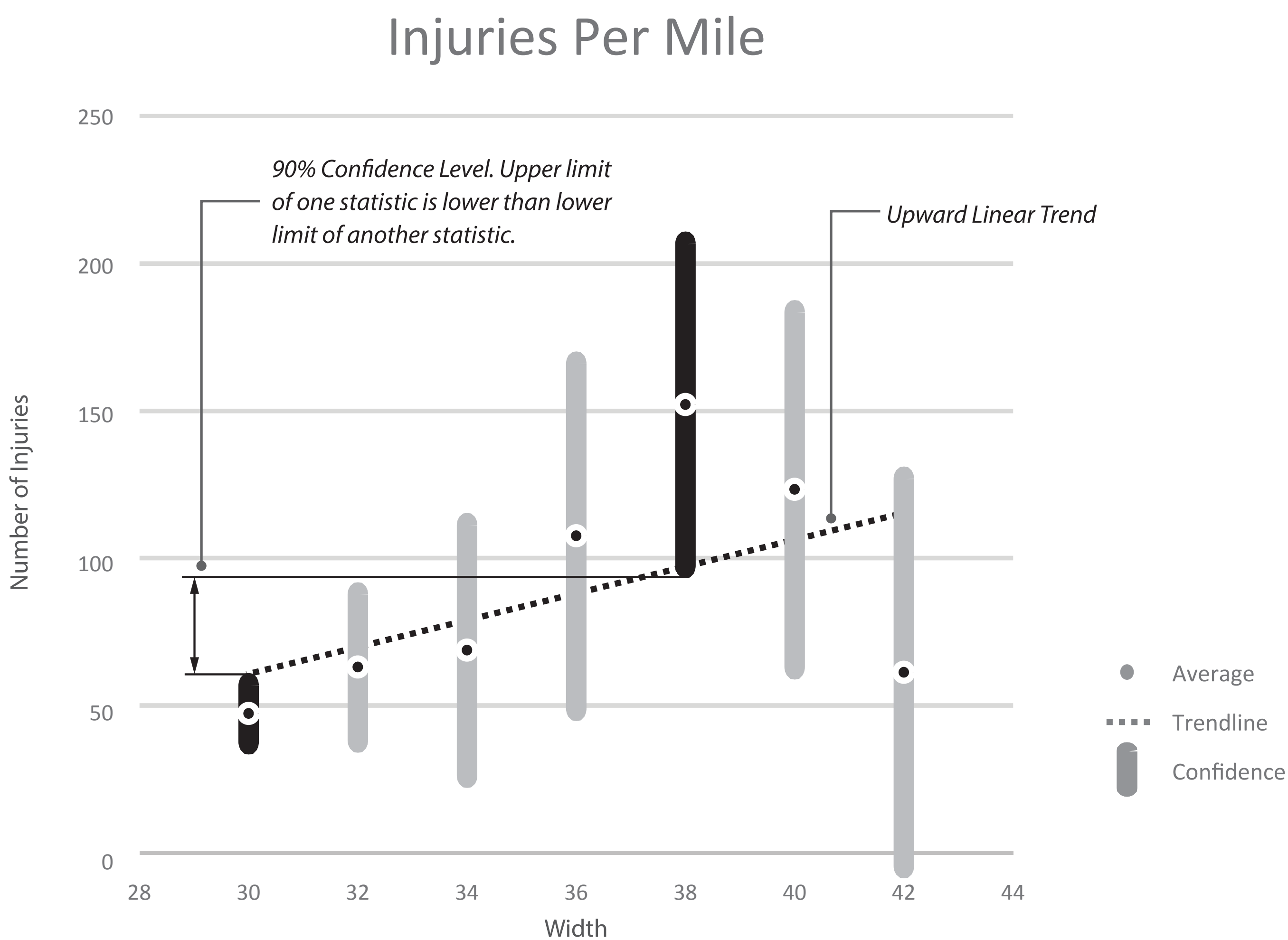
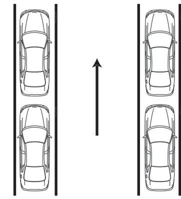
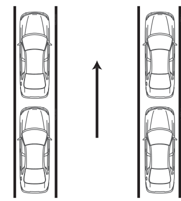
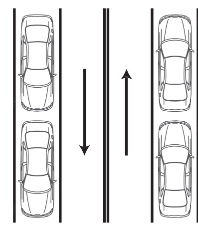
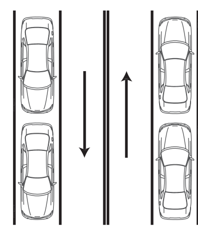
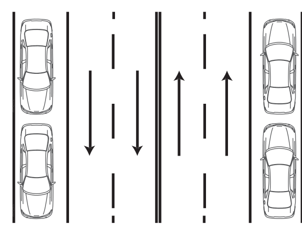


Fig. 17. **CONFIDENCE CHART FOR PEDESTRIAN INJURIES**

Confident that 30' and wide streets are safer than 38' wide streets.

Table 3. **RESULTS FROM STREET WIDTH STUDY**

Upward trends and confidence level statistics from Street Width Study.

ONE-WAY **MID RISE/COMMERCIAL**		**TREND**	
		CONFIDENCE	
ONE-WAY **SINGLE FAMILY/ LOW RISE**		**TREND**	
		CONFIDENCE	
TWO-WAY **MID RISE/COMMERCIAL**		**TREND**	
		CONFIDENCE	
TWO-WAY **SINGLE FAMILY/ LOW RISE**		**TREND**	
		CONFIDENCE	
TWO-WAY **FOUR TRAVEL LANES**		**TREND**	
		CONFIDENCE	

	KSI/ MILE	PEDESTRIAN INJURIES/MILE	MOTOR INJURIES/MILE	BICYCLE INJURIES/MILE	TOTAL INJURIES/MILE
	↑	↑	↑	↑	↑
			✓		✓
	↓	↑	↑	↑	↑
		✓	✓	✓	✓
	↓	↑	↑	↑	↑
	↑	↑	↑	↑	↑
		✓			
	↑	↑	↑	↑	↑

↑ *Trend that Narrower Streets are safer*

✓ *90% Confidence*

↓ *Trend that Wider Streets are safer*

Data Source:
NYCDOT Database
Injury data: NYSDOT/NYSDMV Accident Database
Fatality data: NYCDOT/NYPD Reconciled Fatality Database

The second way to analyze the data is to categorize by injury type (vertical analysis of table 3 on the previous page). Four out of five injury categories including pedestrian, motor, bicycle, and total injuries, had an upward trend in all street types studied. The remaining injury category, KSI, had an upward trend in three street types. Three of the injury categories had a 90% confidence level in two street types.

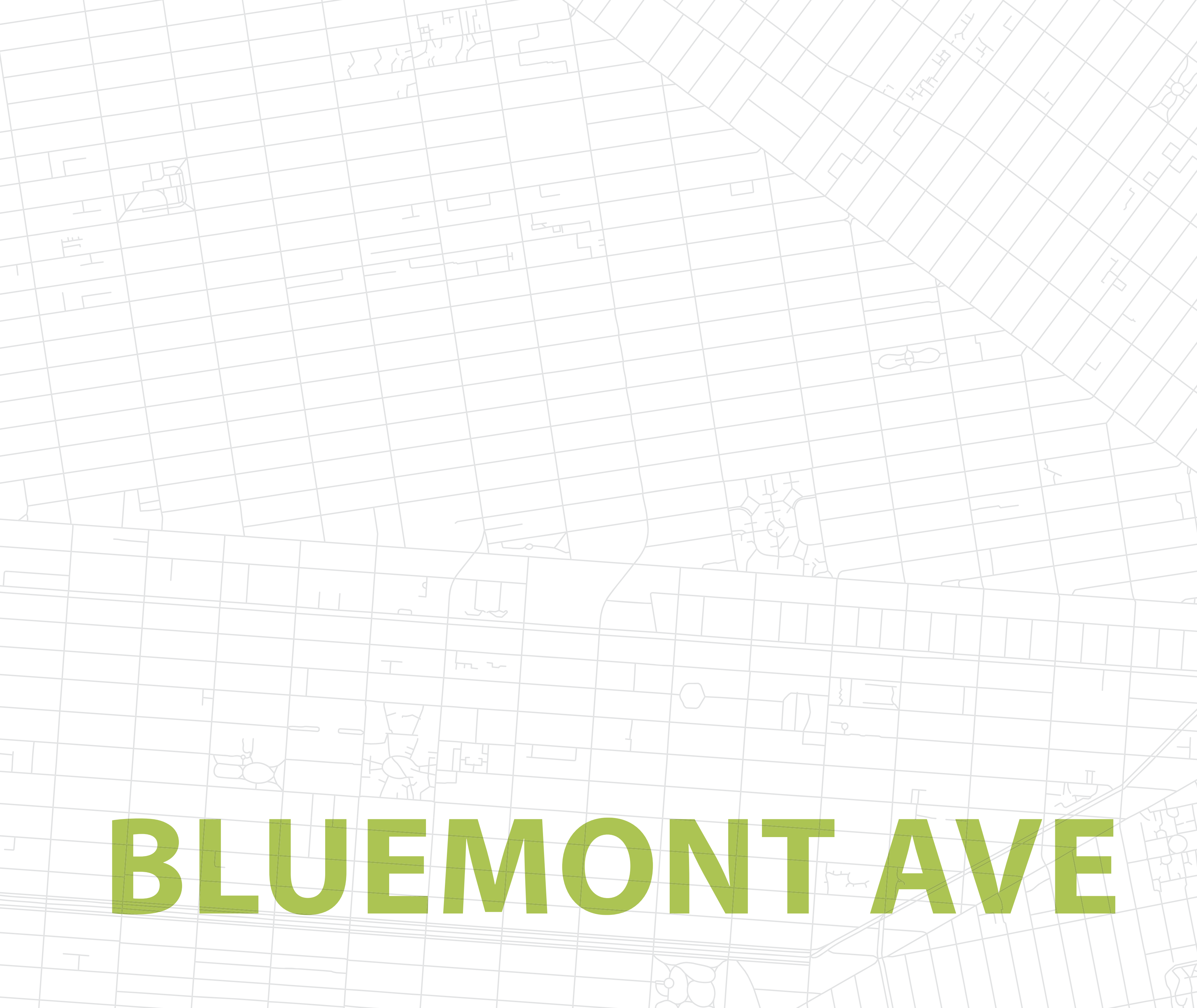
Limitations

While the street width study resulted in strong trends towards narrower streets being safer for all modes of transit, the completed study is an introductory exploration. The primary limitation of this study is the lack of volume data for the streets analyzed. Although land use was used to control for volume data, further study is needed using actual volume data.

The second limitation results from unforeseen variables. As all research was conducted off site, it is unknown whether variables such as number of signalized intersections, number of formalized crossing areas, and frequency of traffic violations, such as jaywalking, remained constant across all streets sampled. The final limitation is the unique character of New York City. Pedestrians are a key component of the city and the transferability of the results of the study to cities with lower volumes of pedestrians is unknown.

Conclusions

While limitations are apparent in the study, this exploratory research supports the hypothesis that narrower streets are safer for pedestrians. 92% of statistics studied reveals an upward trend for all modes of transit while all street types studied have an upward trend that narrower streets are safer for pedestrians. By utilizing the results of the correlation study, a designer can strengthen their argument to narrow wide, auto-dominated streets.



BLUEMONT AVE

BLUEMONT DESIGN PROPOSAL

“WHAT STRATEGIES CAN BE UTILIZED TO INCREASE PEDESTRIAN SAFETY ON BLUEMONT AVENUE IN MANHATTAN, KANSAS?”

The results of the NYC Street Width Study justify the narrowing of Bluemont Avenue (figures 18-22). The design intervention is a two-stage process beginning with a low investment, low risk temporary proposal utilizing NYCDOT strategies. The temporary design would serve as a test project if implemented. Following design and review of the temporary intervention, including feedback from a City of Manhattan engineer, the researcher produced a permanent design proposal was produced.

Fig. 18. **EXISTING CONDITIONS**

Intersection of Bluemont Avenue and Juliette Street.


SITE LIMIT
12th St.
11th St.
MANHATTAN AVE.
S
S

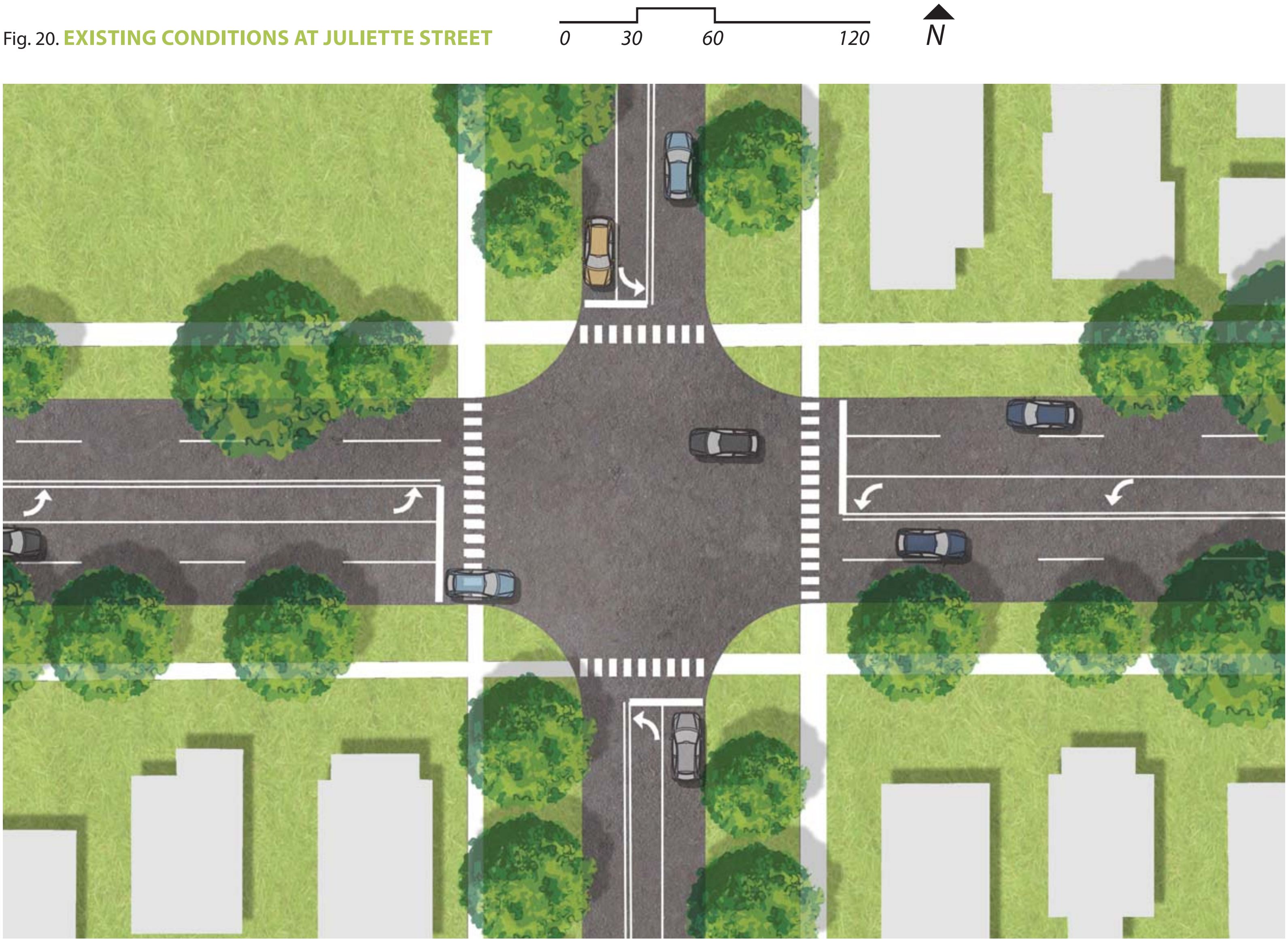

MATCHLINE
8th St.
Juliette St.
6th St.

Fig. 19. **BLUEMONT AVENUE EXISTING CONDITIONS**

11th Street to 4th Street. Base Data by City of Manhattan.

0 75 150 300 N

Fig. 20. **EXISTING CONDITIONS AT JULIETTE STREET**



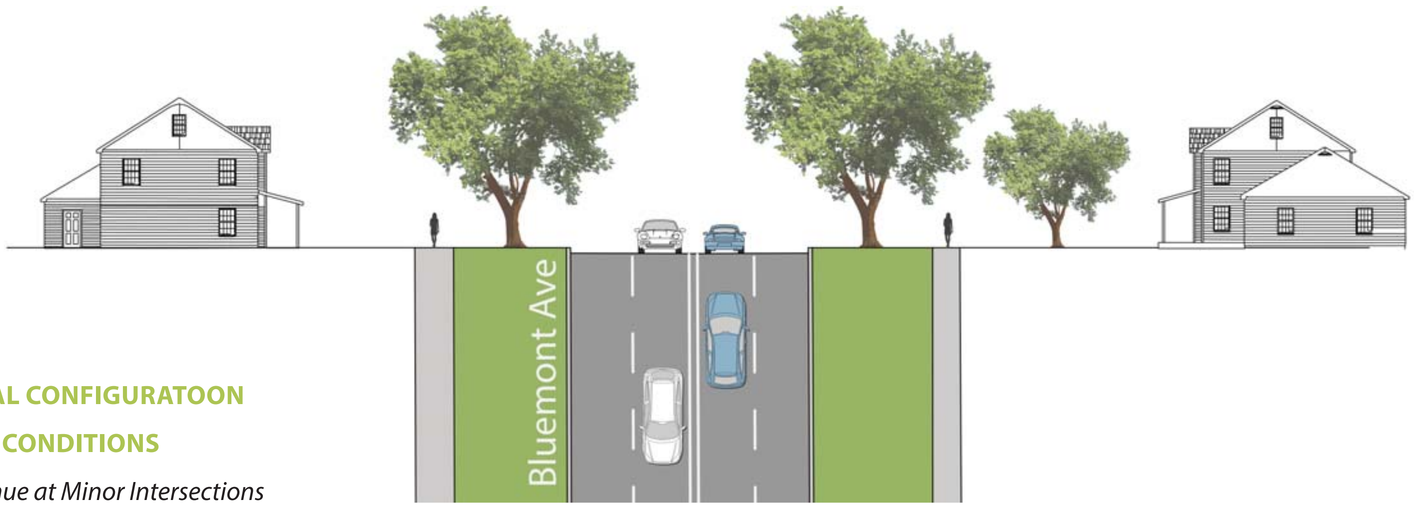


Fig. 21. **TYPICAL CONFIGURATOON OF EXISTING CONDITIONS**

Bluemont Avenue at Minor Intersections

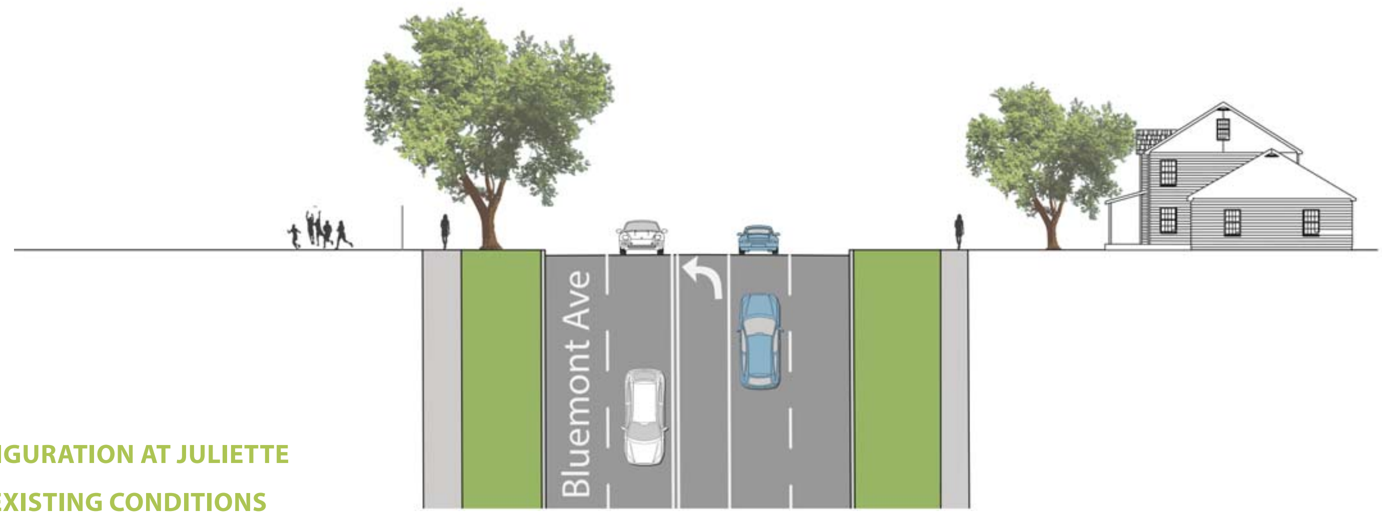


Fig. 22. **CONFIGURATION AT JULIETTE STREET OF EXISTING CONDITIONS**

ANALYSIS

Site Context

Bluemont Avenue functions as a major corridor for vehicular traffic moving between east and west Manhattan, Kansas (figure 23). The avenue contains four moving lanes, except at the intersections of Juliette Street, 11th Street and Manhattan Avenue. At these locations, the street has been widened to accommodate dedicated left-turn lanes. Bluemont Avenue was widened at Juliette Street in 2009 and again between 11th Street and Manhattan Avenue in the fall of 2013.

Bluemont Elementary is located approximately halfway along the corridor. While the school serves students from the northern portions of Manhattan, the surrounding community utilizes the playground in front of the building facing Bluemont Avenue as a park.

The current configuration of Bluemont Avenue allows for pedestrian movement across the avenue at five locations (figure 24). Three locations are on the western end of the corridor while the other two are at Juliette Street and the eastern end of the corridor. These five locations along a 4,000-foot corridor are the only points where a pedestrian can cross the street with the assistance of a pedestrian signal. None of the remaining intersections contains signals and a pedestrian would be required to cross the street at their own risk. The long

Study Street

Arterial

Collector

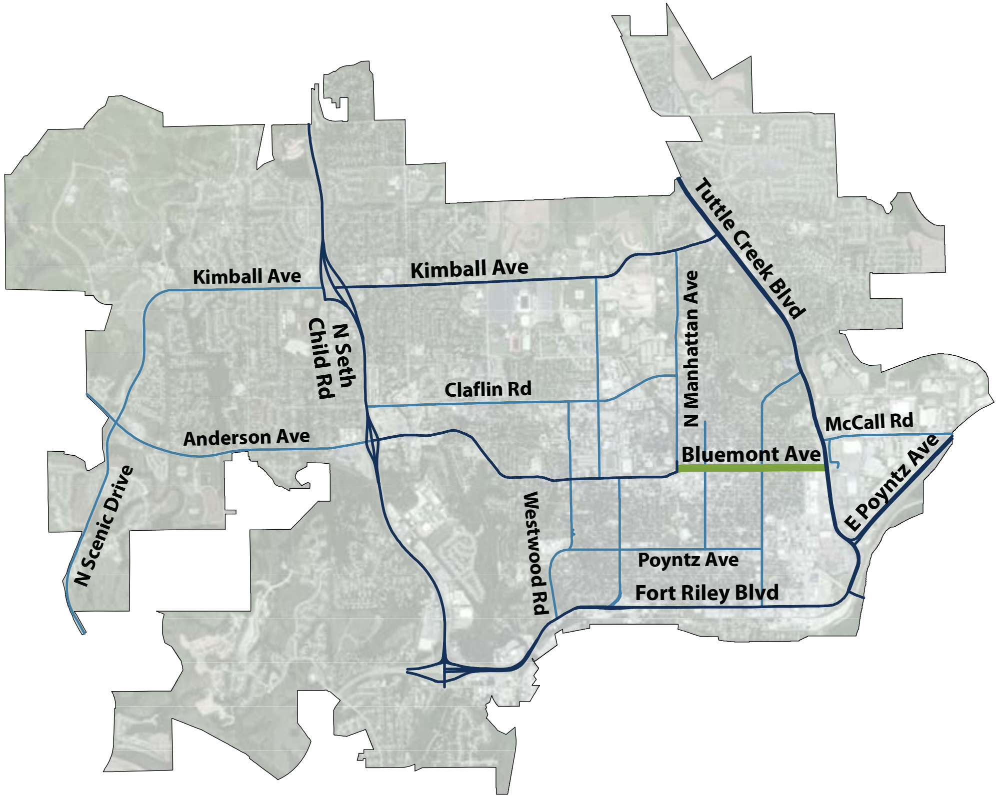


Fig. 23. **ARTERIAL CONTEXT OF BLUEMONT AVENUE**

Surrounding arterials can accommodate increased traffic volumes resulting from decreasing the capacity of Bluemont Avenue. Base Data by City of Manhattan.

Fig. 24. **CROSSWALK LOCATIONS**

Permeability across Bluemont Avenue is limited due to limited crosswalks, signalized intersections, and wide crossing distances along the .8 mile long corridor. Base Data by City of Manhattan.

crossing distance (over four or five lanes of traffic) is the primary deterrence to the movement of pedestrians from one side of Bluemont to the other.

Signal Analysis

Currently, actuated signals control traffic at signalized intersections along Bluemont Avenue. The signals switch the phasing of the intersection once activated by vehicle. Figure 25 shows the intersection of Bluemont Avenue and Juliette Street. The three-phase configuration contains a dedicated left-turn phase for Bluemont Avenue traffic, but not for Juliette Street traffic. The intersection at 11th Street and Bluemont Avenue is a four-phase signal allowing the traffic movements show in figure 26. Traffic moving east and west along Bluemont Avenue has a dedicated left-turn phase while only northbound traffic on 11th Street has a dedicated left-turn phase.

Volume Analysis

In general, traffic is higher during the PM peak hour than in the AM peak hour. Traffic counts were taken at the two signalized intersections along the corridor: 11th Street and at Juliette Street (figure 27). In general, traffic volumes are consistent along the corridor. The predominant movement of cars is east to west along the corridor.

Volume data combined with signal phasing creates a Level of Service (LOS) Grade for each intersection. The intersection at Bluemont Avenue and 11th Street ranks overall as a C. The average delay for the intersection is 20.5 seconds per vehicle. East-west movements along Bluemont Avenue function more efficiently (B- LOS) than the north-south movements along 11th Street (C-LOS).

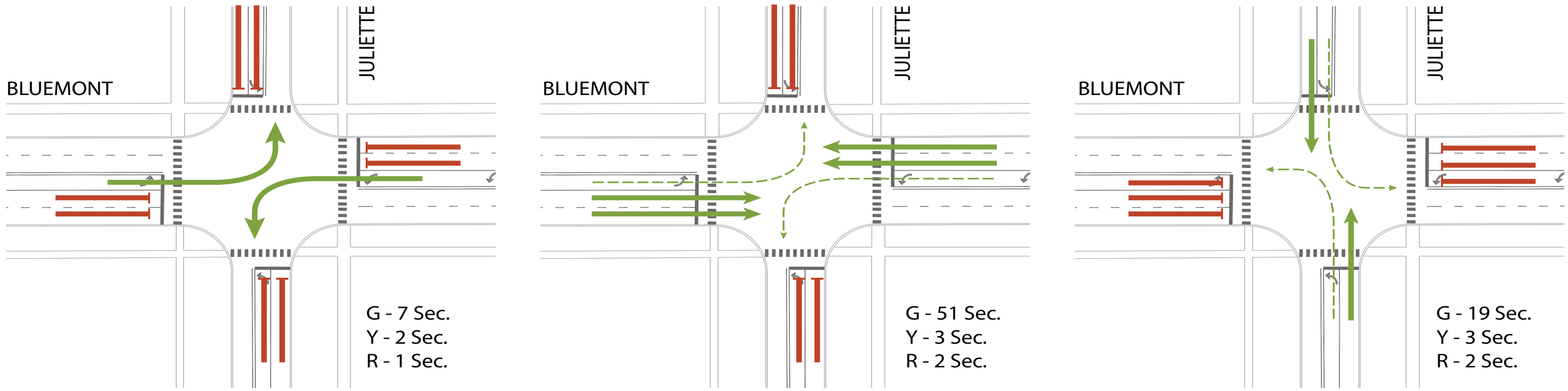


Fig. 25. **EXISTING SIGNAL PHASING FOR BLUEMONT AVENUE AT JULIETTE STREET**

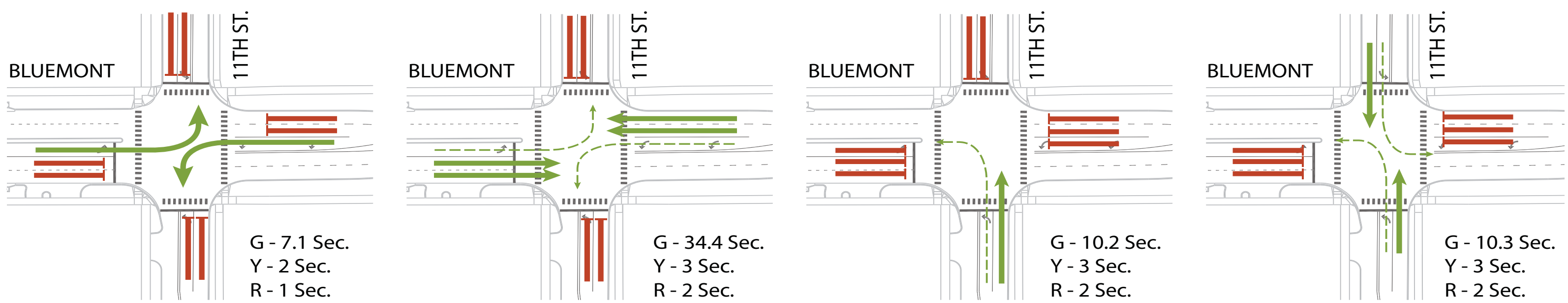


Fig. 26. **EXISTING SIGNAL PHASING FOR BLUEMONT AVENUE AT 11TH STREET**

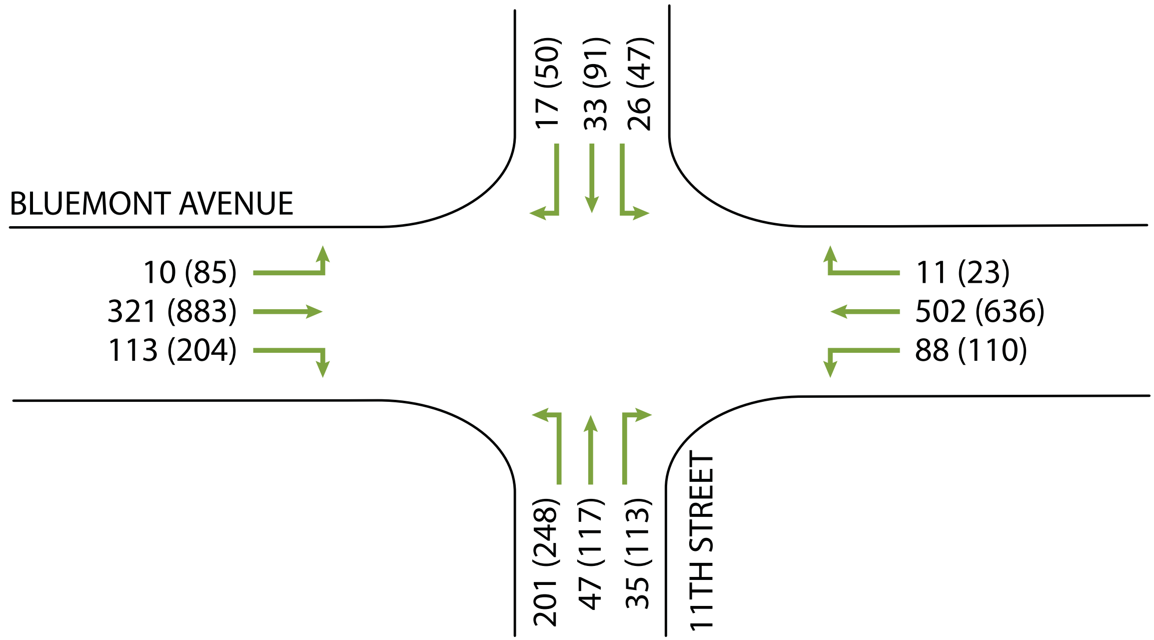
Traffic Volumes are slightly lower at Juliette Street and Bluemont Avenue resulting in a slight increase in the level of service. The intersection as a whole is a C-LOS intersection with an average delay of 16.4 seconds per vehicle. Individual movement grades are similar to those at 11th Street with Bluemont Avenue receiving a B-LOS and Juliette Street receiving a C-LOS.

Safety Data

The primary reason the city of Manhattan is looking to widen Bluemont Avenue is to add a left-turn lane along the entire length of the corridor. By adding this lane, the city hopes to reduce the number of left turn related collisions. Conflicts between vehicles turning left against traffic flow and rear-ends between left-turners and the drivers behind them make up the majority of crashes that occur along Bluemont Avenue.

Limitations

According to the Highway Safety Manual (2010), the primary way a safety study is conducted is to find comparison sites to the proposed street to compare safety statics. Due to the limited number of arterial roadways in Manhattan and the unique context of Bluemont Avenue, a comparison study was deemed unfeasible. The results from the NYC street width study are used as justification for the narrowing of Bluemont Avenue.



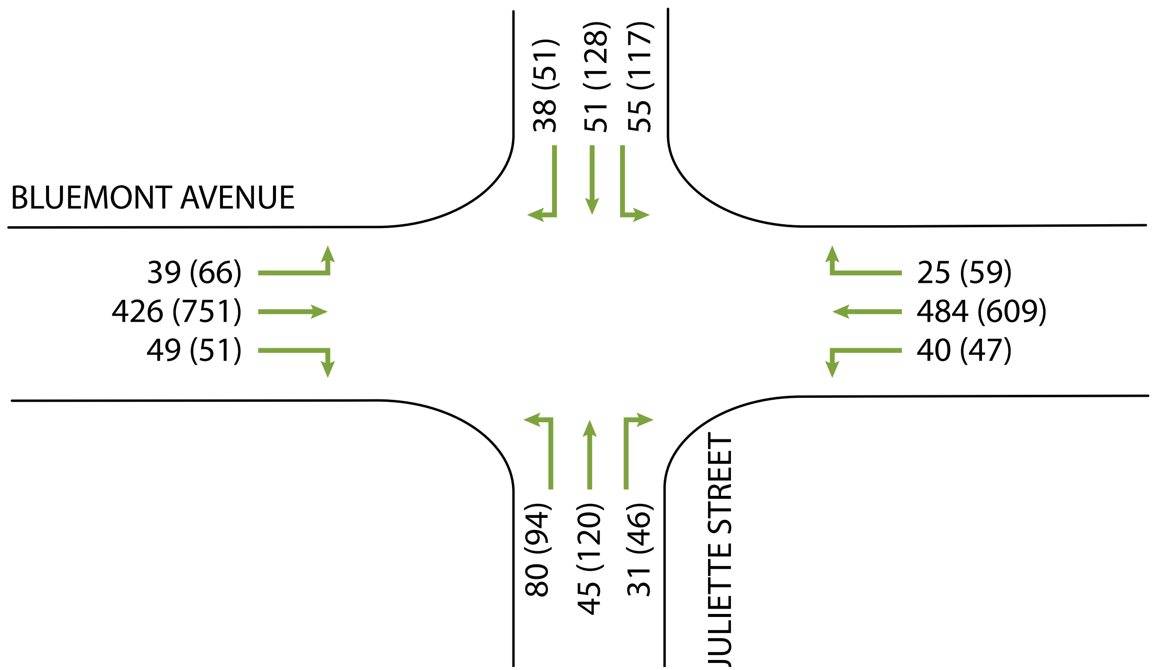


Fig. 27. **TRAFFIC VOLUMES**

Traffic volumes are higher along Bluemont Avenue, as shown by examining two cross streets. City of Manhattan.

Design

A two-stage design process (figure 28) was utilized to increase the feasibility of implementation of the Bluemont Avenue design. The first stage created a temporary design that utilizes strategies developed at NYCDOT. The primary objective of the design was to narrow Bluemont Avenue while adding left-turns lanes at all intersections along the corridor, signalized and signalized.

The final street design reconfigured Bluemont Avenue from a two-lane, two-way street into a two-way street with a central turning lane along the entire length (figure X). The new configuration would remove one travel lane in each direction and meet the cities goal of reducing rear-ends and collisions associated with cars turning left at minor intersections.

The proposed design does come at a cost to traffic efficiency. The removal of a travel lane in each direction limits the capacity of each intersection. While both intersections remain at the existing C-grade, individual movements have an increase in the average delay and receive a decreased grade.

At 11th Street, the average delay increases by 10 seconds to 30.44 seconds per vehicles. Westbound Bluemont Avenue remains at its existing B-grade while eastbound traffic decreases to a C-grade. Both north and south bound traffic on 11th Street decreases from the existing C-grade to a D-grade; however, the delay increase is only 15 seconds for northbound traffic and 5 seconds for southbound traffic.

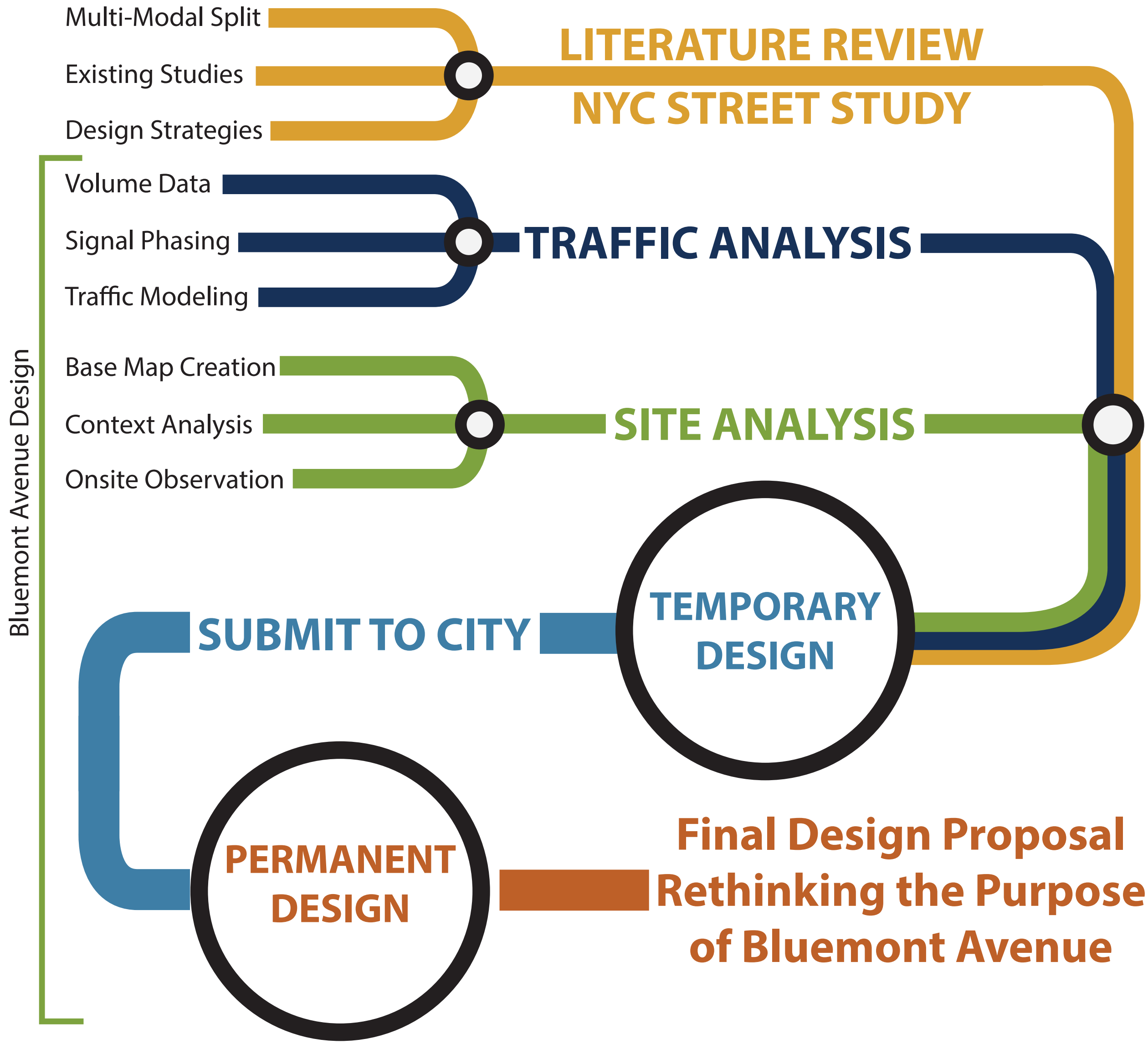


Fig. 28. **DESIGN PROCESS**

Fig. 29. **WATER STREET TEMPORARY INSTALLATION**

Use of flexible bollards and paint at Water Street in New York, NY. Used with permission from NYCDOT. 2014.

At Juliette Street and Bluemont Avenue, the intersection maintains the original C-grade. The average delay increases from 16.4 seconds to 28.5 seconds per vehicle. North and southbound traffic on Juliette Street maintains the C-grade and only experiences a 2-3 second increase in delay. Eastbound Bluemont Avenue drops from a B-grade to a C-grade and increases the average delay to 31.9 seconds. Westbound traffic remains at a b-grade and increases the average delay to 19.6 seconds.

While traffic efficiency is slightly decreased, the primary benefit to narrowing the roadbed is increased pedestrian safety. Pedestrian can now cross the street along the entire corridor of Bluemont Avenue. Instead of an auto-dominated arterial, Bluemont would become a street for multiple modes of transit.

TEMPORARY STREET DESIGN

Proposal One

After completing traffic analysis and concluding that reducing the width of Bluemont Avenue was feasible, two design proposals were created. Each proposal looks at narrowing Bluemont using a different technique. The first design narrows the avenue by moving the curb lines closer to the centerline. The second proposal narrows the avenue by adding a central median.

The temporary proposals utilized strategies developed at NYCDOT (figure 29) to create designs that would be low cost and low impact. By using paint and flexible bollards to delineate new lane configurations, the city has the option to

Fig. 30. **TEMPORARY DESIGN PROPOSAL ONE**

Intersection of Bluemont Avenue and Juliette Street.

revise a design after implementation easily, and cost effectively. The city would be able to test the low risk temporary designs before permanent installation.

Proposal one (figures 30-34) would utilize paint and flexible bollards to move the "curb lines" of Bluemont Avenue closer to the centerline. The space can be occupied by pedestrians to shorten the crossing distance and allow for better visibility by drivers turning right onto another street. The new curb lines would also provide more of a buffer between pedestrians walking along Bluemont Avenue and traffic.

One of the major benefits of this configuration is the addition of bus service along Bluemont Avenue. Currently, bus stops are not available as there is no dedicated space for a bus to pull out of traffic to pick up passengers. By narrowing Bluemont Avenue, the unused lanes at Juliette and 11th Street are converted into dedicated bus stops.


MANHATTAN AVE.
12th St.
SITE LIMIT
11th St.
S

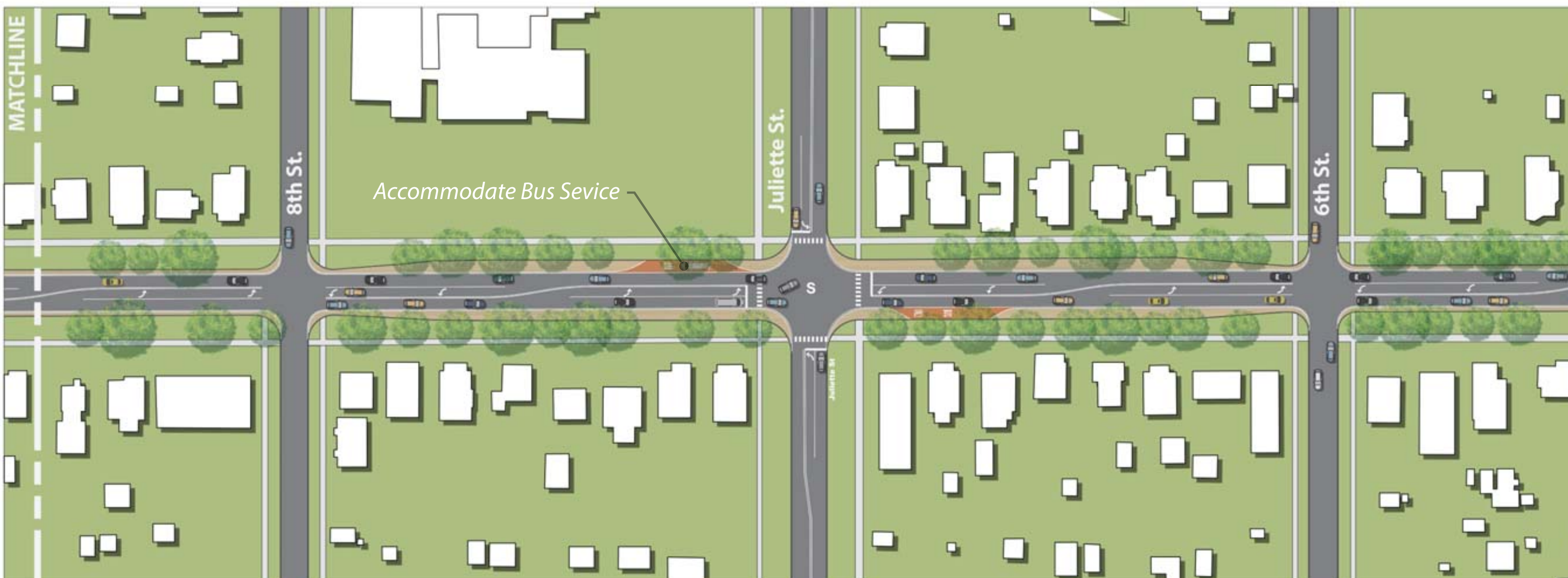

MATCHLINE
8th St.
Accommodate Bus Sevice
Juliette St.
6th St.
S

Fig. 31. **BLUEMONT AVENUE TEMPORARY DESIGN ONE**

from 11th Street to 4th Street. Base Data by City of Manhattan.

0 75 150 300

N

Fig. 32. **TEMPORARY PROPOSAL ONE AT JULIETTE STREET**

0 30 60 120 N

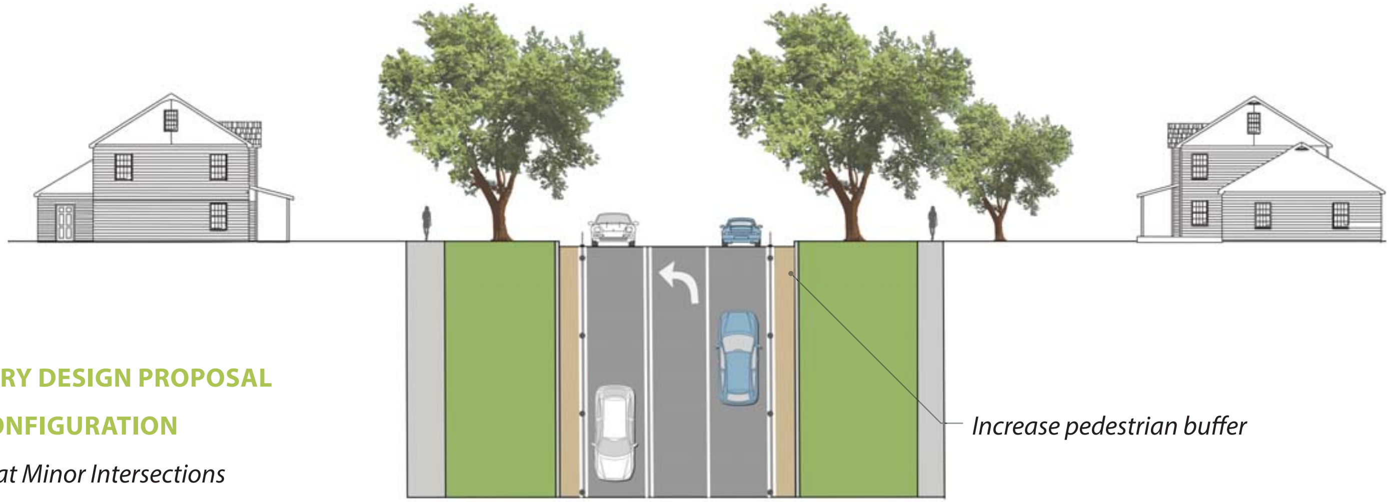


Fig. 33. **TEMPORARY DESIGN PROPOSAL ONE TYPICAL CONFIGURATION**

Bluemont Avenue at Minor Intersections

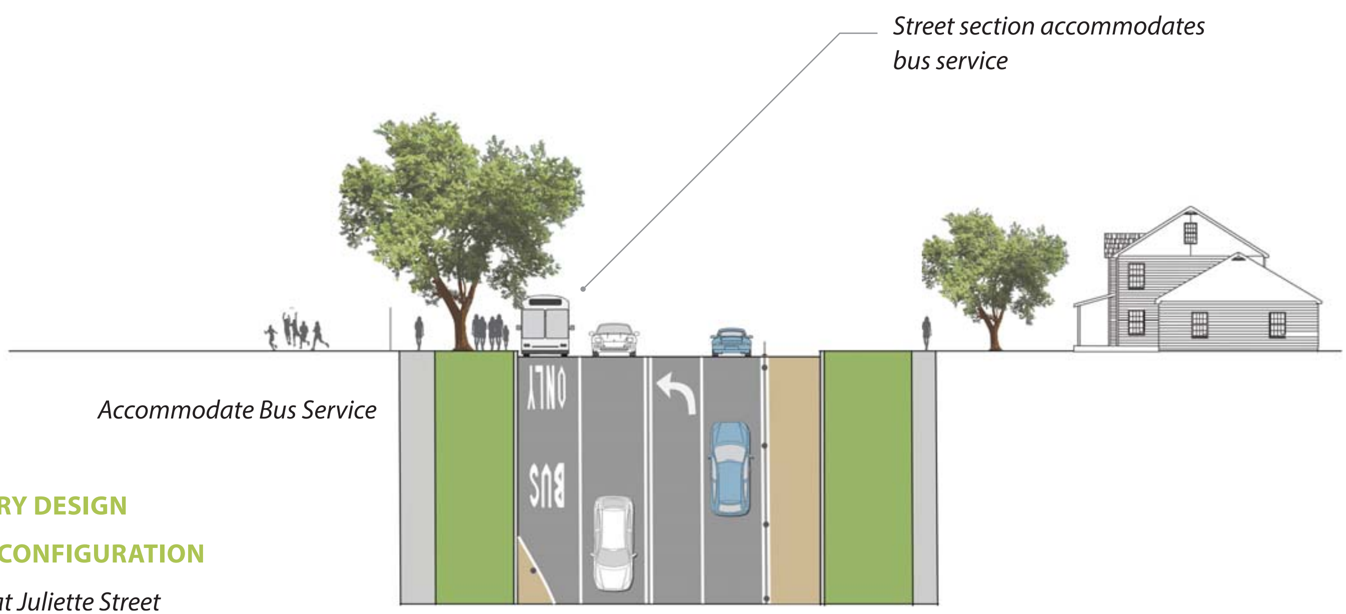


Fig. 34. **TEMPORARY DESIGN PROPOSAL ONE CONFIGURATION**

Bluemont Avenue at Juliette Street

Fig. 35. **TEMPORARY DESIGN PROPOSAL TWO**

Intersection of Bluemont Avenue and Juliette Street.

Proposal Two

Proposal Two (figures 35-39) creates a center median and moves traffic out towards the curb lines. The new configuration would allow pedestrians to occupy the median to cross Bluemont Avenue. By breaking up the crossing distance into two sections, pedestrians would be able to cross at unsignalized intersections safely.

While the median configuration does not allow for bus service along Bluemont Avenue, the median creates a safer environment for pedestrians. The median also serves as a buffer between traffic moving in different directions along Bluemont Avenue.


SITE LIMIT
12th St.
11th St.
MANHATTAN AVE.
S


MATCHLINE
8th St.
Juliette St.
6th St.

Fig. 36. **BLUEMONT AVENUE TEMPORARY DESIGN TWO**

from 11th Street to 4th Street. Base Data by City of Manhattan.

0 75 150 300

N

Fig. 37. **TEMPORARY PROPOSAL TWO AT JULIETTE STREET**

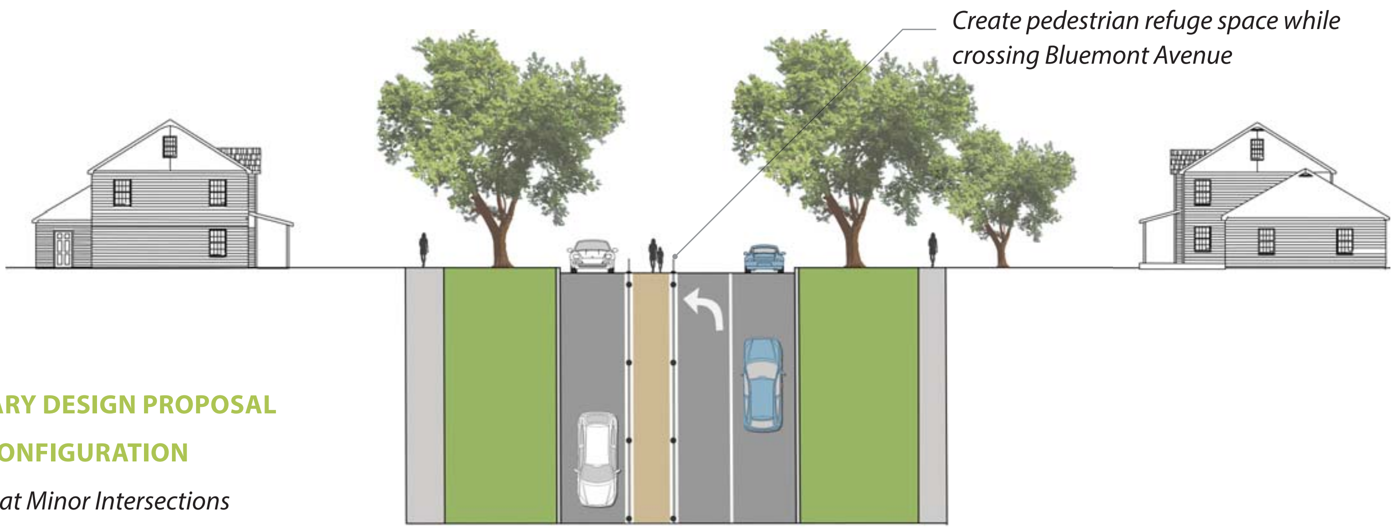


Fig. 38. **TEMPORARY DESIGN PROPOSAL TWO TYPICAL CONFIGURATION**

Bluemont Avenue at Minor Intersections

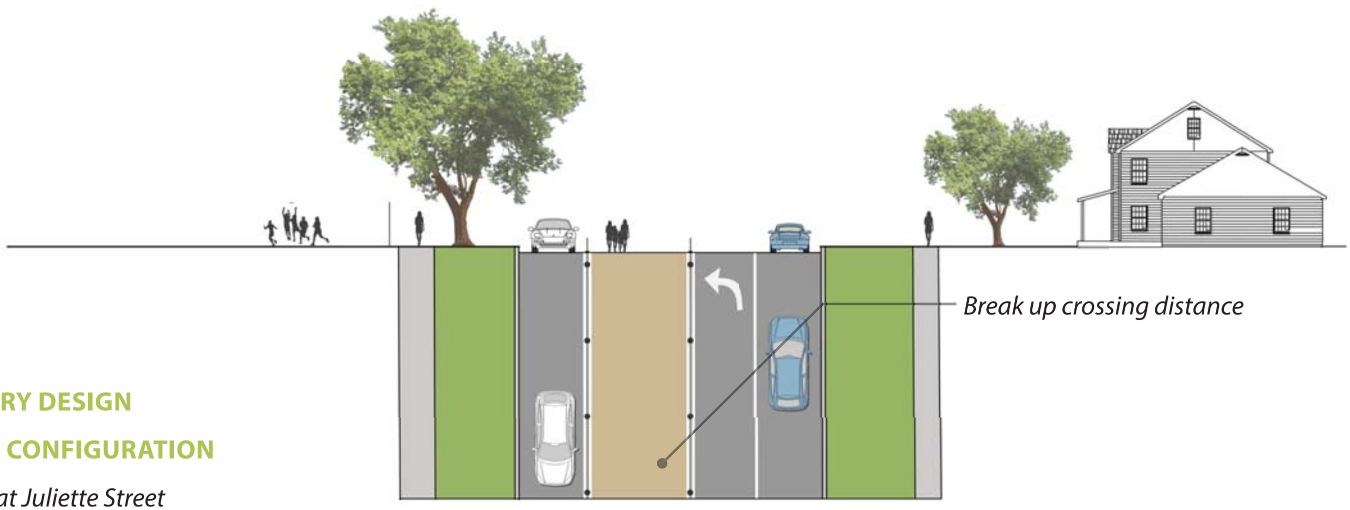


Fig. 39. **TEMPORARY DESIGN PROPOSAL TWO CONFIGURATION**

Bluemont Avenue at Juliette Street

Review Process

A mid-critique was held after completing the temporary design. Committee members as well as a Peter Clark, City of Manhattan Civil Design Engineer, provided comments and suggestions (figure 40) before beginning the permanent proposal design process. Katie Kingery-Page provided input from the viewpoint of a designer and landscape architect, Robert Stokes from the viewpoint of a traffic engineer, Ben Champion as a sustainability advocate, and Peter Clark as a city engineer.

Fig. 40. **FEEDBACK FROM MID-CRIT**

KATIE KINGERY-PAGE

Create two strong, independent concepts, not two options for one concept

ROBERT STOKES

Recognize that the Bluemont Avenue design is not simply narrowing the roadway, but utilizing traffic calming measures

BEN CHAMPION

Looking at argument from Traffic Engineers Point-of-View
Recognizing that increasing pedestrian safety reduces traffic capacity

PETER CLARK, CITY OF MANHATTAN

Planning for future growth of Manhattan and increased traffic volumes

Fig. 41. **PERMANENT DESIGN PROPOSAL ONE**

Intersection of Bluemont Avenue and Juliette Street.

PERMANENT STREET DESIGN

Following the mid-critique, the temporary design was developed into a permanent proposal (figures 41-45). The painted curb lines were converted into new concrete curbs and spaces for plantings and bus stops were delineated. Proposal one extended the curb lines into the street to create a large tree terrace. The enlarged terrace would provide space to reestablish the oak tree line that borders both sides of Bluemont Avenue. In addition, a permanent bus stop with benches and shelter along with brick paving establishes spaces for transit riders to wait and board. Sidewalks would be extended and accommodate new handicapped curb ramps.


SITE LIMIT
12th St.
11th St.
MANHATTAN AVE.


MATCHLINE
8th St.
Juliette St.
6th St.

Fig. 42. **BLUEMONT AVENUE PERMANENT DESIGN ONE**

from 11th Street to 4th Street. Base Data by City of Manhattan.

0 75 150 300

N

Fig. 43. **PERMANENT PROPOSAL ONE AT JULIETTE STREET**

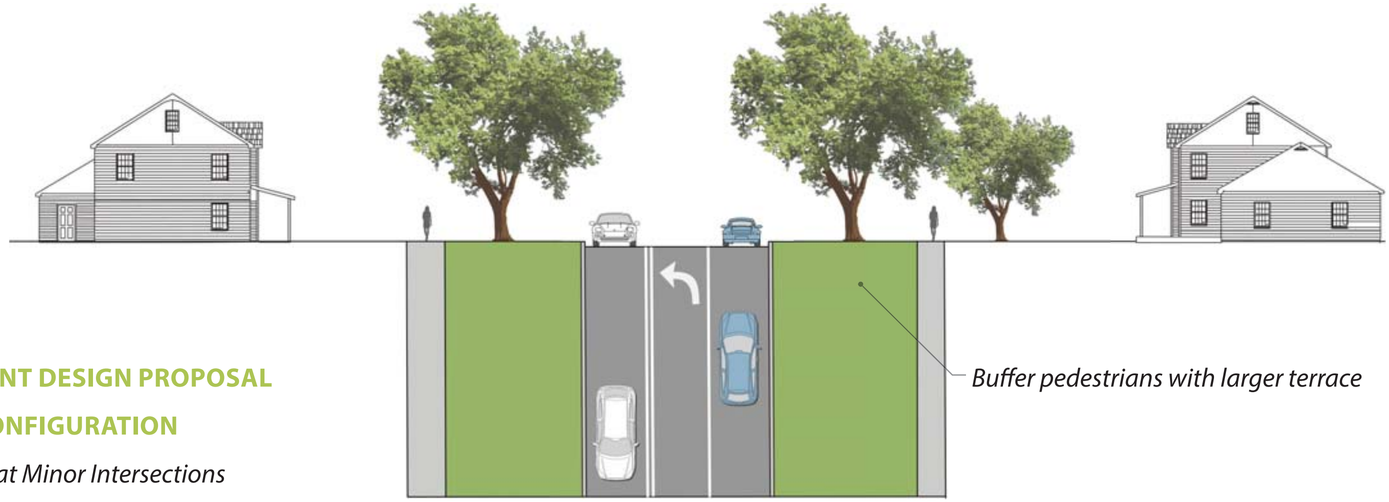


Fig. 44. **PERMANENT DESIGN PROPOSAL ONE TYPICAL CONFIGURATION**

Bluemont Avenue at Minor Intersections

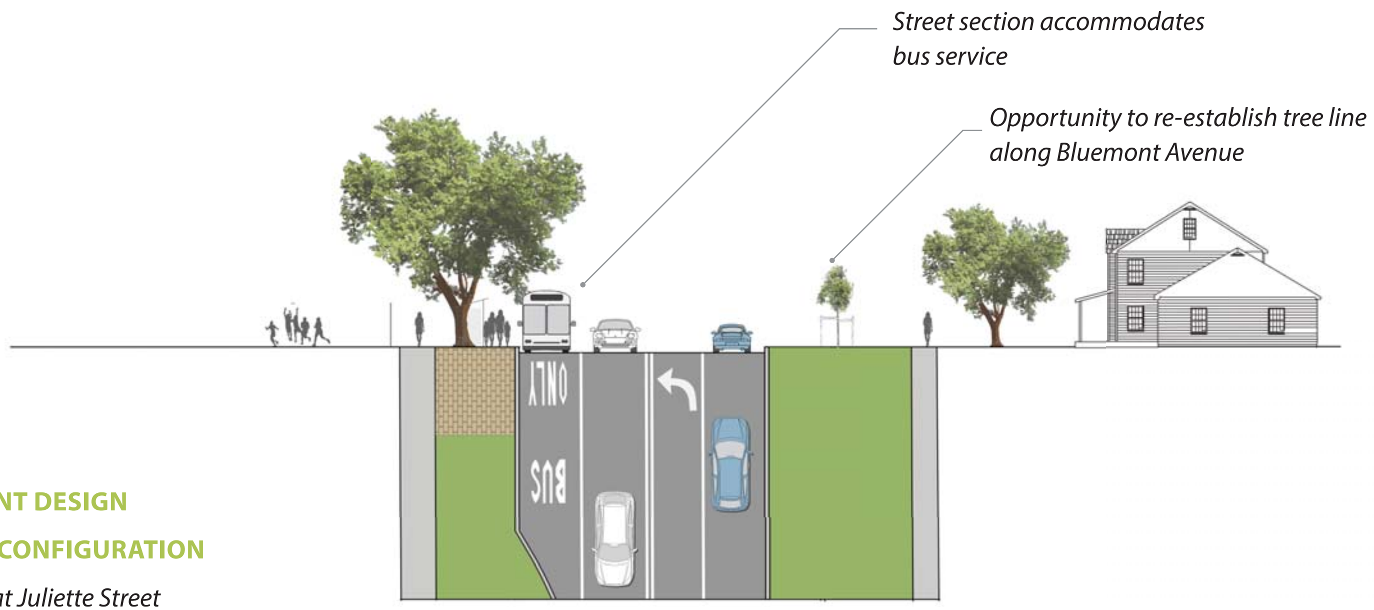


Fig. 45. **PERMANENT DESIGN PROPOSAL ONE CONFIGURATION**

Bluemont Avenue at Juliette Street

Fig. 46. **PERMANENT DESIGN PROPOSAL TWO**

Intersection of Bluemont Avenue and Juliette Street.

Proposal Two (figures 46-50) adds a central median to Bluemont Avenue. Larger sections of the median provide space to include boulevard style plantings in the center of the street. At intersections, the median functions as a pedestrian refuge island for people crossing the street. The islands are especially useful at unsignalized intersections, breaking up the crossing distance into two sections, which allows more movement across Bluemont Avenue.


SITE LIMIT
12th St.
11th St.
MANHATTAN AVE.
S


MATCHLINE
8th St.
Juliette St.
6th St.

Fig. 47. **BLUEMONT AVENUE PERMANENT DESIGN TWO**

from 11th Street to 4th Street. Base Data by City of Manhattan.

Fig. 48. **PERMANENT PROPOSAL TWO AT JULIETTE STREET**

0 30 60 120

N

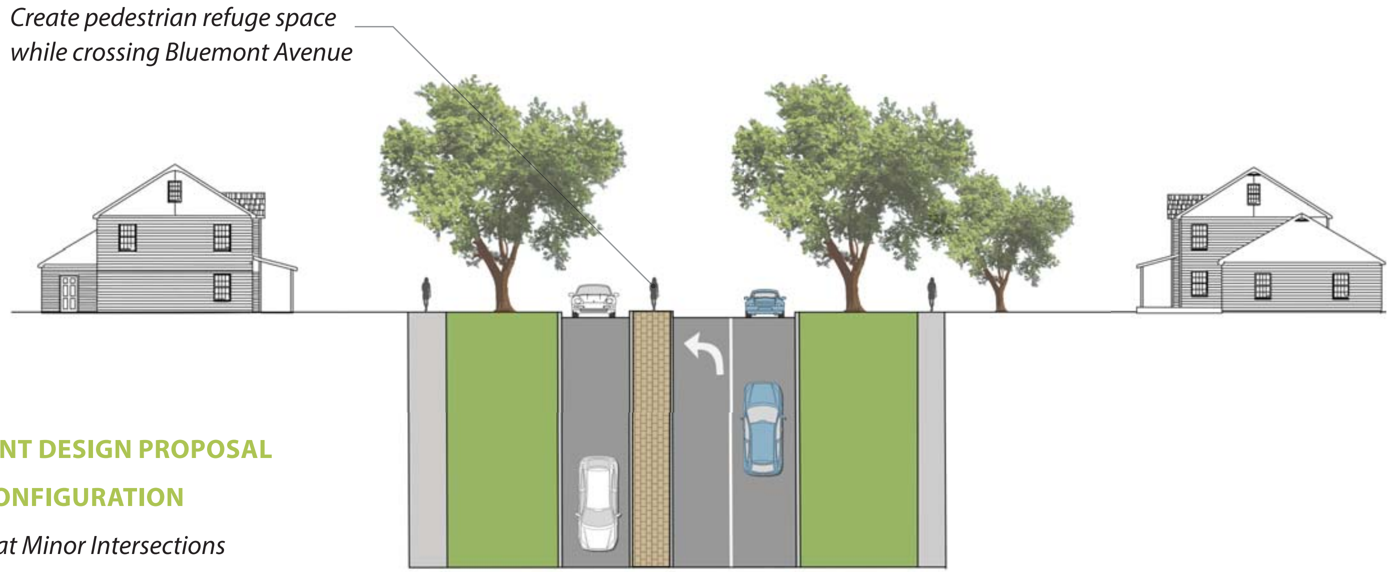


Fig. 49. **PERMANENT DESIGN PROPOSAL**

TWO TYPICAL CONFIGURATION

Bluemont Avenue at Minor Intersections

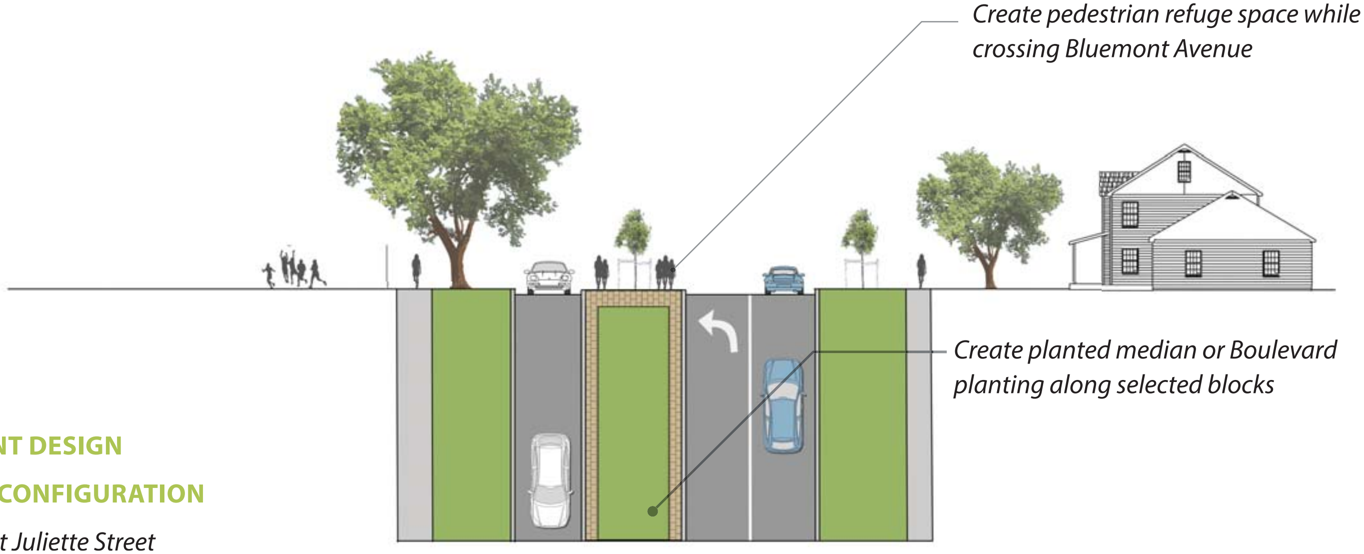


Fig. 50. **PERMANENT DESIGN PROPOSAL TWO CONFIGURATION**

Bluemont Avenue at Juliette Street

Post Design

Upon completing the design process, comments of committee members and the City of Manhattan were taken and analyzed. The main concern was looking at how to translate the goals of the design and meet the needs of traffic engineers. The design would need to accommodate not only existing conditions, but future conditions as the City of Manhattan grows.

ENDINGS

REFLECTIONS

Future Traffic Volumes

While the design proposals for Bluemont Avenue accommodate existing traffic conditions, future conditions need to be considered. The City of Manhattan plans to widen Bluemont Avenue (figures 51 and 52) to increase safety as well as accommodate growth. Peter Clark, City of Manhattan, suggested completing signals analysis using predicted traffic conditions over the next 20 years. Over the past 20 years, traffic volumes have increased by 34.6%. The city believes that the increase will remain constant over the next twenty years. Only thru volumes were increased by 34.6%, as the city believes the other turning movements are fully built out.

When the traffic volumes were increased to accommodate 20 years of growth in the city of Manhattan, the proposed designs failed and the Level of Service dropped to an F-Grade. In order to make the design proposals for Bluemont Avenue feasible, one must rethink the purpose of Bluemont Avenue.

Rationale for rethinking the purpose of Bluemont

Two arguments were used to justify rethinking the purpose of Bluemont Avenue. The first is context. Bluemont Avenue is one of the main connection streets between the east and west sides of Manhattan, Kansas. However, if the priority of Bluemont Avenue was decreased and traffic growth along the corridor remained constant, the surrounding arterials would be able to accommodate the future growth.

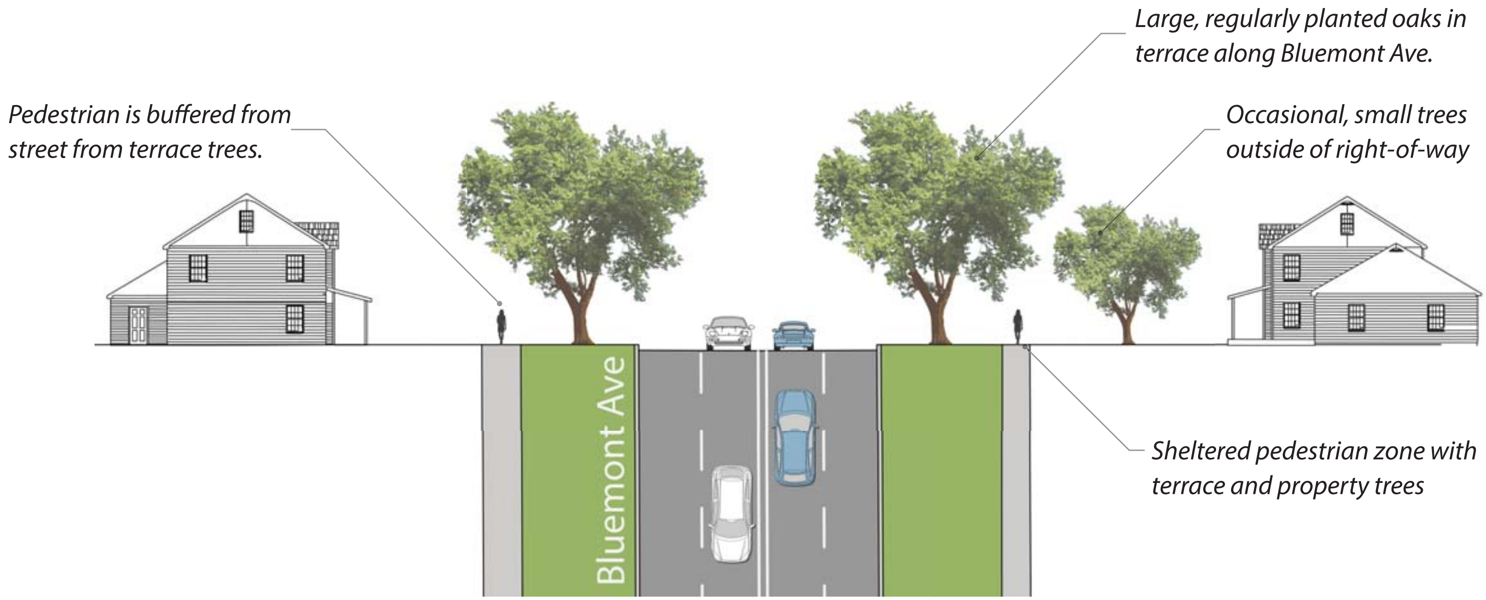


Fig. 51. **TYPICAL CONFIGURATION OF BLUEMONT**

Four Lanes with left-turn lanes at major intersections.

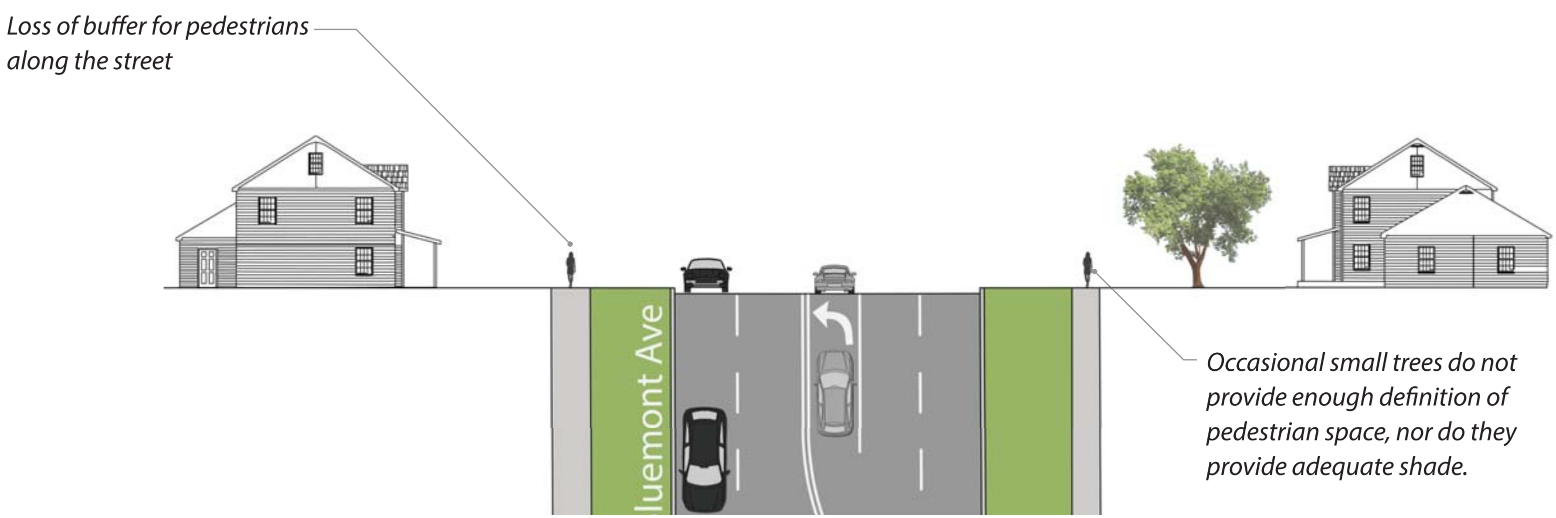


Fig. 52. **CITY'S PROPOSED CONFIGURATION OF BLUEMONT**

Proposed plan accommodates a left-turn lane along the entire length.

The argument for utilizing the surrounding arterial to meet traffic needs is further reinforced by looking at the future growth of Manhattan (figure 53). Currently, major projects are being located along the northern portions of campus along Kimball Avenue. The National Bio and Agro-Defense Facility (NBAF) is currently under construction in the north. Kimball Avenue will accommodate traffic needs by the new employer and destination.

The 2025 campus Master Plan for Kansas State University looks to utilize the stadium parking lots as all-university parking lots with frequent shuttles carrying students, faculty, and staff to and from campus. Kimball Avenue will also accommodate the increased traffic from this new use. Finally, the future of the university lies to the north and west of the current campus. Future development plans call for university expansion to be incorporated into the neighborhoods surrounding Claflin Avenue and Denison Avenue. As the future of Manhattan moves to the north and west, the priority of Bluemont Avenue in the eastern portion of the city can be decreased.

Character

The second argument to justify rethinking Bluemont Avenue is character of the street corridor. Bluemont Avenue functions as one of the "front doors" to Manhattan and to the University. Visitors arriving from the north and from the east will more than likely enter into the heart of the city and the university by utilizing Bluemont Avenue. Currently, the character of Bluemont Avenue is likened to an urban, tree-lined street. The future design plans proposed by the city would destroy this character

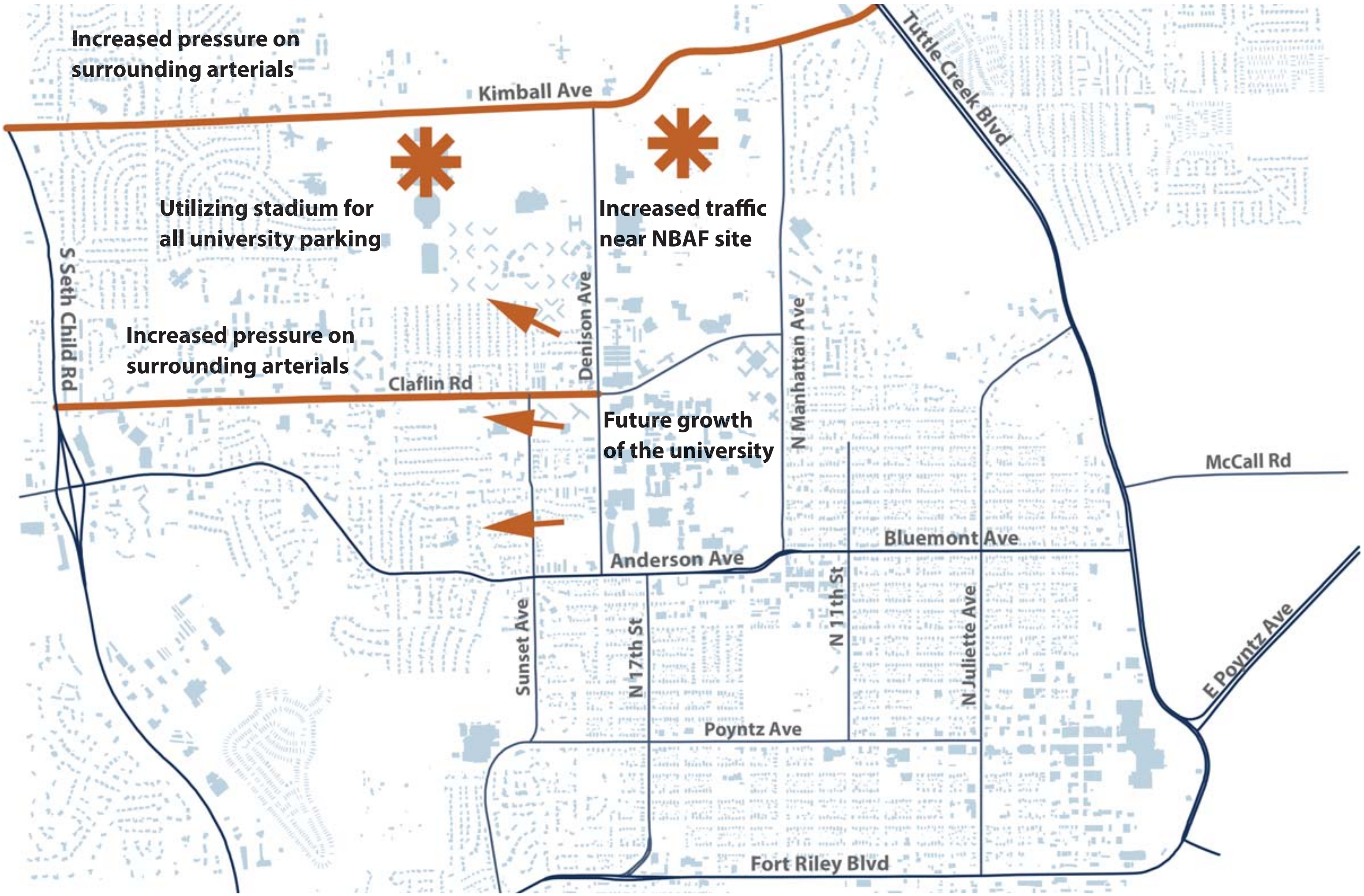


Fig. 53. **FUTURE GROWTH OF MANHATTAN, KANSAS**

Manhattan is growing away from Bluemont Avenue allowing the avenue to be decreased in priority for moving traffic. Base Data by City of Manhattan.

by accommodating a wider street and removing the trees. Tree removal may occur intentionally, or as an inadvertent result of construction in tree root zones.

In total, 106 trees are at risk of removal by the proposed city plan (figure 54). While the trees may not be removed immediately following reconstruction of the roadway, the change in the curb lines could result in a slow process of trees dying and being removed over the next ten years.

Thirty-three trees are currently at risk of removal from the widening of Bluemont Avenue at Juliette Street in 2009 construction. One tree has already been removed due to disturbances caused by the construction. Seven trees are at risk from the widening at 11th Street and Manhattan Avenue in 2013. Six trees have already been removed due to the 2013 construction.

If the city's plan is carried forward and Bluemont Avenue is widened to accommodate left turn lanes along the entire corridor, sixty-six additional trees would be put at risk of removal. The loss of the street trees would irreparably change the character of Bluemont Avenue, create an increasingly inhospitable environment for pedestrians, and add to the urban heat island effect.

Successes and Trade-offs for each permanent design proposal

The two design proposals each have a unique element that must be considered when deciding which to implement. Proposal one accommodates bus service along

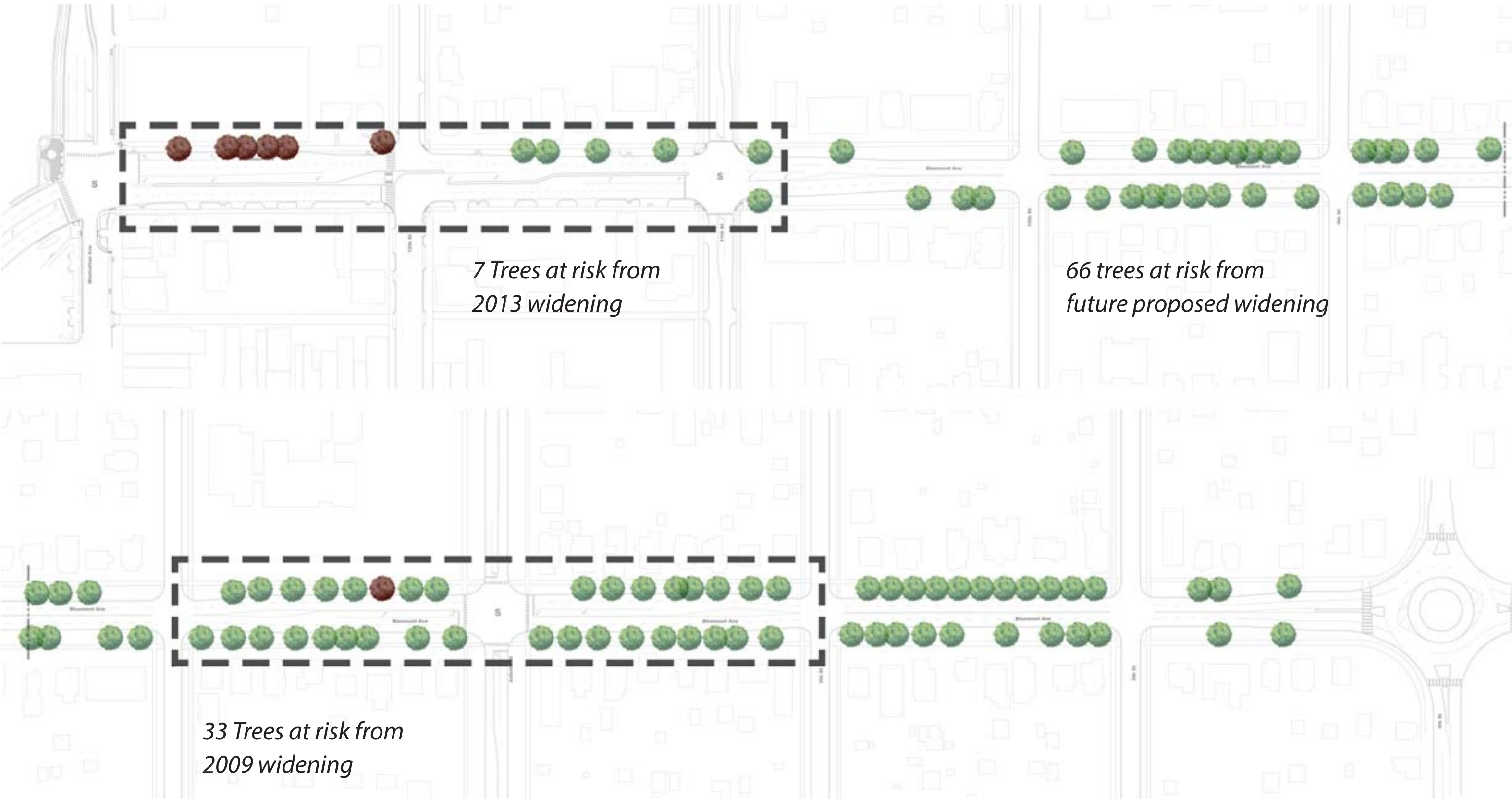


Fig. 54. **TREE LOSS FROM PROPOSED WIDENING**

Potential tree loss from proposed widening would change the character of the Bluemont Avenue corridor. Base Data by City of Manhattan.

Trees that have been removed due to widening

Trees that are at risk due to widening

Bluemont Avenue (figure 55). As this service is currently not available to the residents of the surrounding neighborhoods, the bus service is one of the major successes of proposal one. The bus service would also accommodate a small percentage of the growth projected for Bluemont Avenue, which in turn makes the design more feasible.

While this proposal provides an additional service to people living along Bluemont Avenue, the configuration of the design does not provide the same level of safety to pedestrians as proposal two. While the first proposal is safer than current conditions along Bluemont Avenue, the lack of a central median does not provide a sheltered space for pedestrians crossing Bluemont Avenue at unsignalized intersections.

Proposal two is the more economical option to implement, however routine upkeep costs would be higher to provide maintenance on the planted median. By creating the central median and leaving the existing curb lines, all stormwater management infrastructure can remain in place (figure 56). If the project is implemented, there is no need to rework and move existing infrastructure, creating substantial savings. However, the median offers the opportunity to function as a stormwater management feature. If funding was available, the grade of the street could be adapted and stormwater facilities moved. With this increased investment, the new median could then function as a filter before stormwater entered the sewer system.

The economic feasibility of proposal two is a major benefit of the design. However, with the lack of bus service, the growth of Manhattan is not as well accommodated in proposal two. The city must consider the pros and cons of each proposal when selecting a design proposal to implement.

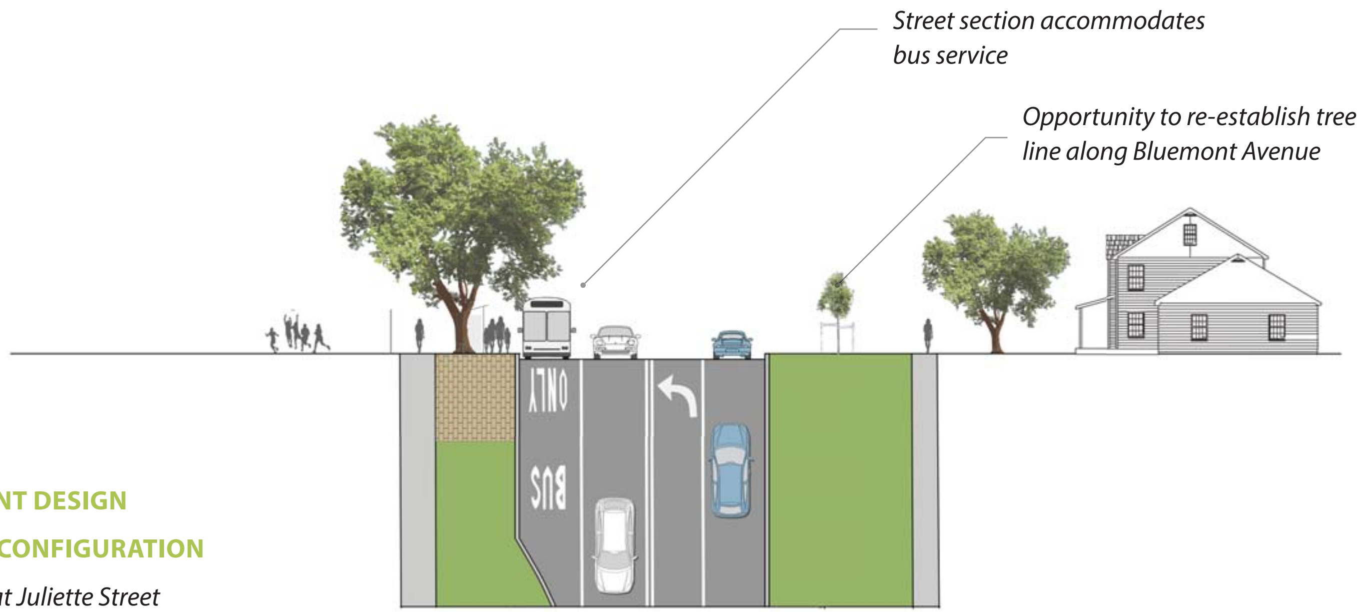


Fig. 55. **PERMANENT DESIGN PROPOSAL ONE CONFIGURATION**

Bluemont Avenue at Juliette Street

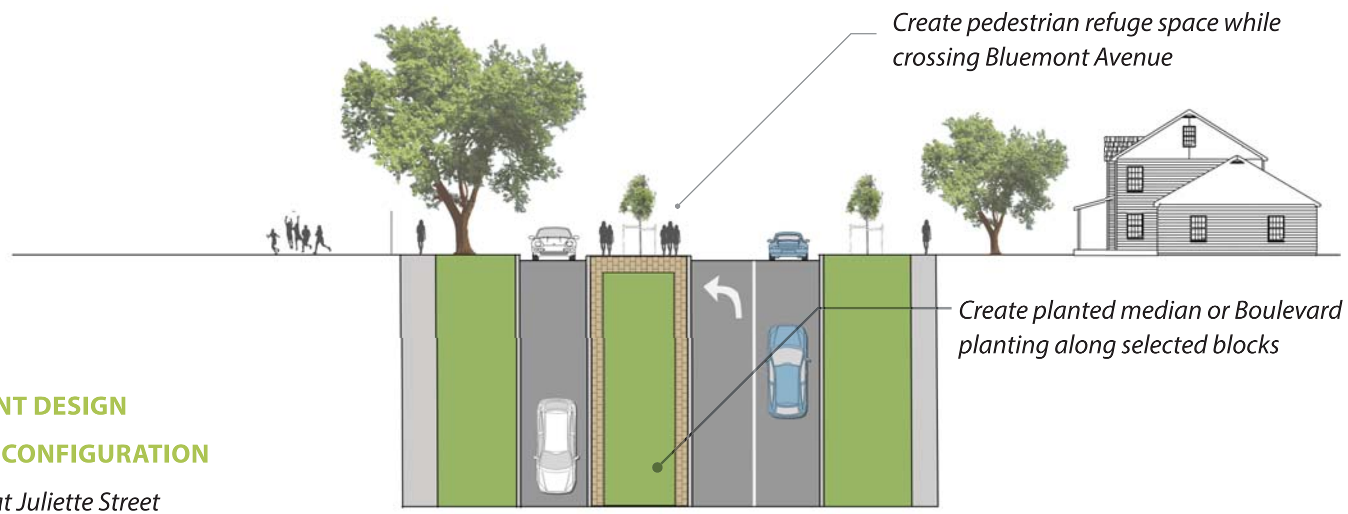


Fig. 56. **PERMANENT DESIGN PROPOSAL TWO CONFIGURATION**

Bluemont Avenue at Juliette Street

Future Research

More research is required to fully justify the need to redesign Bluemont Avenue. If time had been available, a full traffic analysis of the surrounding arterials in Manhattan, Kansas would have strengthened the argument that Bluemont Avenue could decrease in priority within the vehicle hierarchy. The analysis would factor in the growth of the city as well as the increase of traffic on surrounding arterials from the narrowing of Bluemont Avenue.

Secondly, Bluemont Avenue is a segment of a longer corridor. Anderson Avenue is the other half of the urban street that connects east and west Manhattan, Kansas. Further analysis would identify if the remaining portion of the Anderson/Bluemont corridor was eligible for narrowing strategies.

Finally, while the design for Bluemont Avenue was submitted to the city for review, feedback from city engineers was minimal. Factors out of the researchers control such as time and city engineer availability limited the amount of feedback from the city. Future research would ask for more involvement from the City of Manhattan.

FINAL THOUGHTS

Research Questions and Outcomes

"WHAT IS THE CORRELATION BETWEEN STREET WIDTH AND PEDESTRIAN SAFETY?"

"WHAT STRATEGIES CAN BE UTILIZED TO INCREASE PEDESTRIAN SAFETY ON BLUEMONT AVENUE IN MANHATTAN, KANSAS?"

The exploratory research presented in this report supports the hypothesis that narrower streets are safer for pedestrians. By utilizing the results of the study, a designer can strengthen their argument to narrow wide, auto-dominated streets. In addition, the use of a two-stage implementation process can create a safer environment for pedestrians on Bluemont Avenue. By utilizing a temporary design followed by a permanent installation, the City of Manhattan can decrease the priority of Bluemont Avenue within the vehicle hierarchy and increase pedestrian safety.

The combination of the design and correlation study bridges the gap of the original dilemma. The design accommodates traffic while creating a safe environment for pedestrians. Through this strategy of iterative design reinforced with research, the goals of transportation planners and designers can both be achieved.

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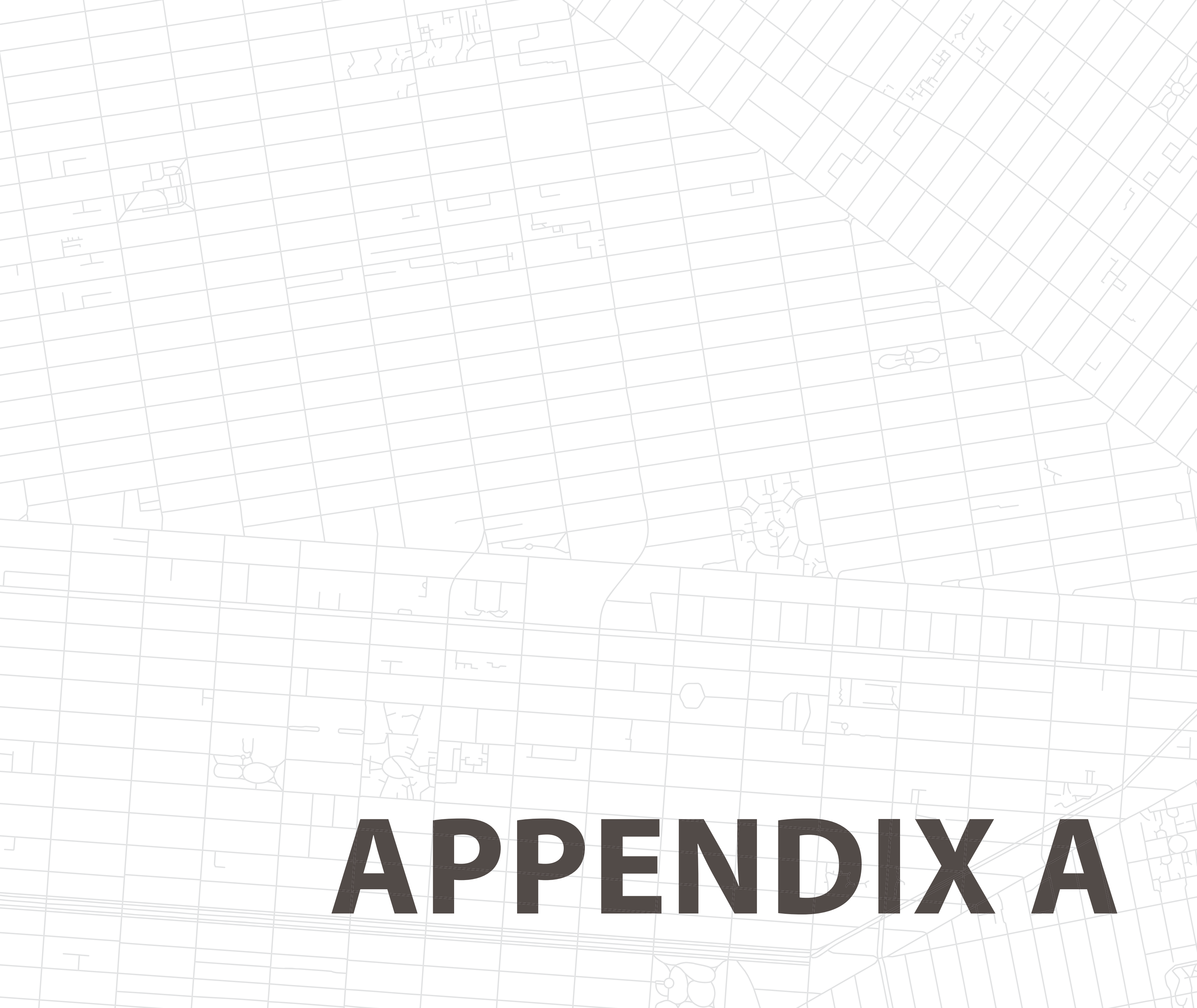
APPENDIX A



GLOSSARY

Accessibility
Ability to reach a range of social, leisure and employment destinations from home (Evans 2009).

Design Speed
Speed governed by geometric features of the roadway and based on street's functional classification (NACTO 2012).

Killed or Severely Injured
Injury causing permanent damage or affecting day to day activities such as hospitalization, leave from work, or decreased mobility (NYCDOT).

Operating Speed
Speed at which the majority of traffic on a given roadway operates or 85th percentile vehicle speed (NACTO 2012).

Passive Street Design
Design principles that favor wide, straight, flat and open roads with clear zones that forgive and account for inevitable driver error (NACTO 2012).

Pedestrian
Any person walking, standing or in a wheelchair (Southworth 2005).

Pedestrian Accident
Any collision between a pedestrian and a moving vehicle on a public right-of-way resulting in injury to or death of the pedestrian (Wang and Smith 1997, pg. 225).

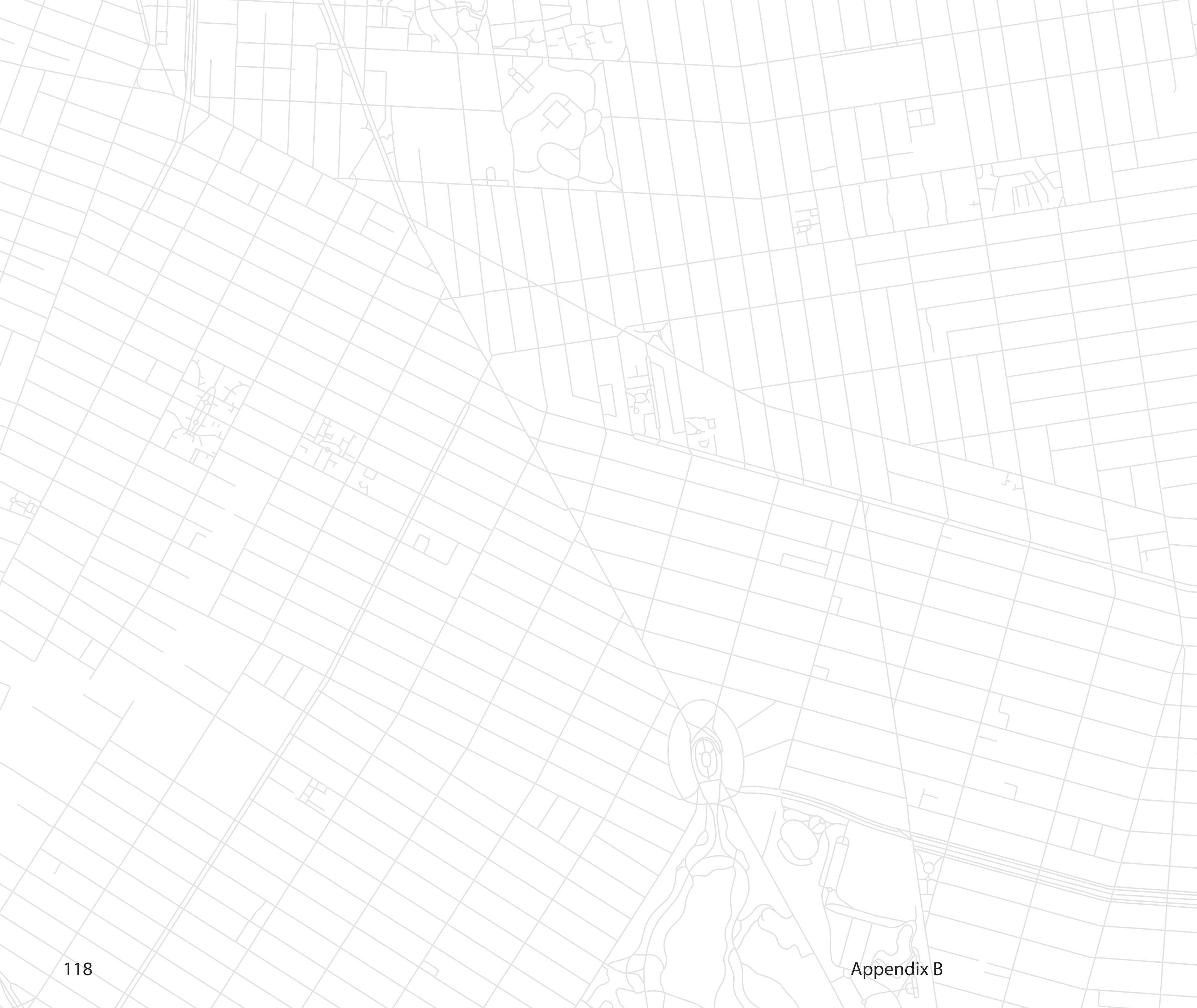
Posted Speed
Speed based on the operating speed and local laws (NACTO 2012).

Proactive Street Design
Design principles that use design elements to affect behavior and lower speeds (NACTO 2012).

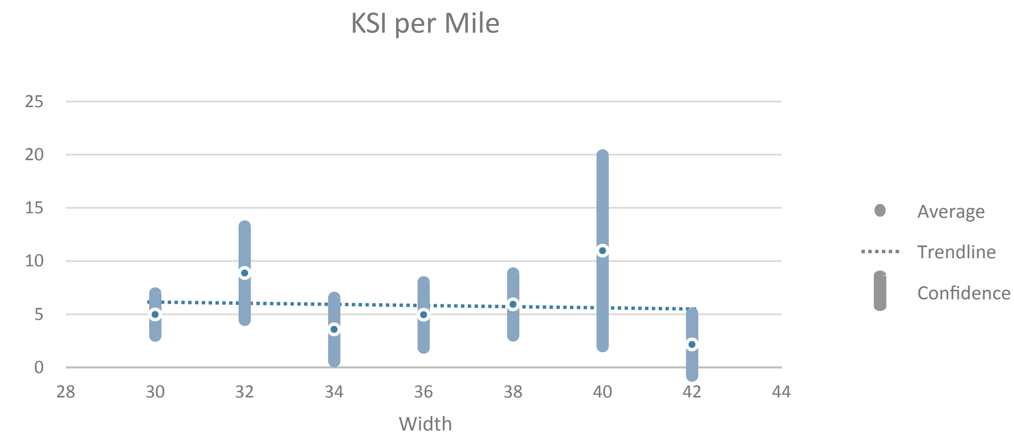
Walkability
The extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network (Southworth 2005).

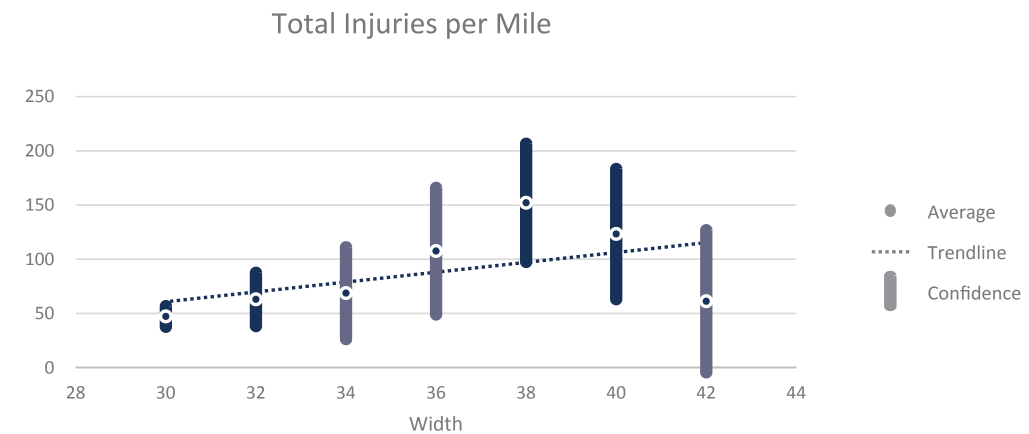
Walkable Community
Thoughtfully planned, designed, or otherwise retrofitted and integrates pedestrian travel into the community's fabric. In a walkable community, walking is a normal transportation choice and is not a distraction or obstacle to motor vehicle traffic (Southworth 2005).

APPENDIX B



STREET WIDTH STUDY DATA



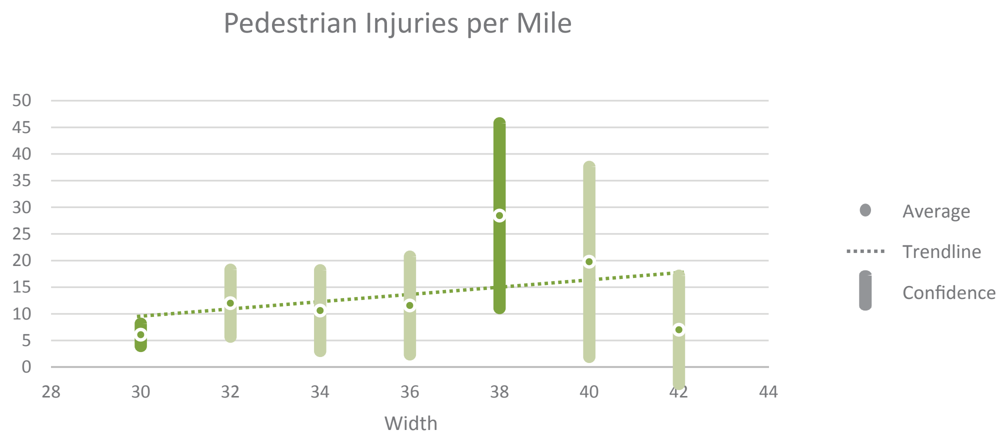


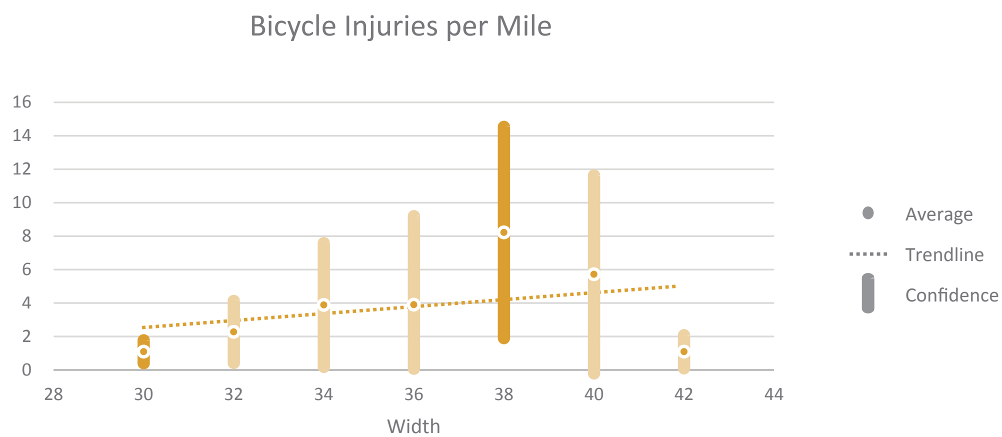
One-Way Streets with Parallel Parking on both sides in Single Family/Low Rise Residential Areas

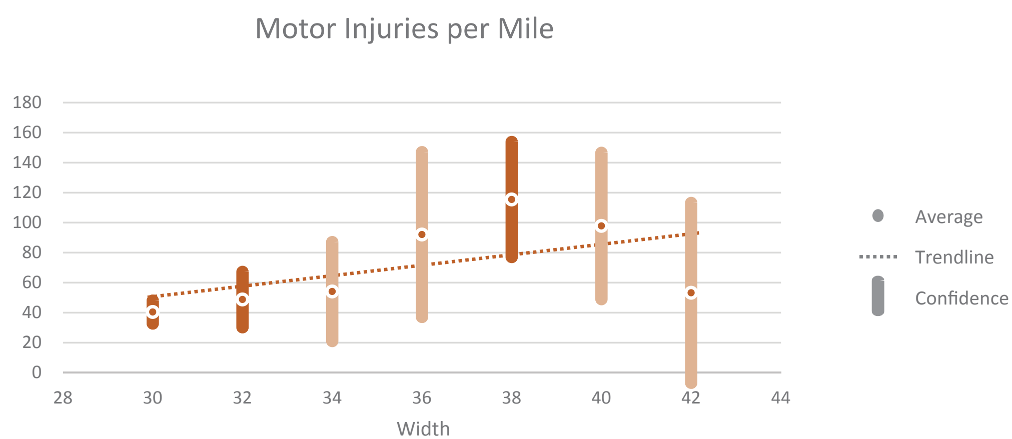
Sample Size	Width	Miles	Avg. # of Inter.	Inter. per mile	Avg. KSI	Avg. KSI /mile	Avg. Ped Injury	Avg. Ped Injuries Per Mile	Avg. Bike Injury	Avg. Bike Injuries Per Mile	Avg. Motor Injury	Avg. Motor Injuries Per Mile	Avg. Total Injuries	Avg. Injuries Per Mile	Avg. Fatalities	Fatalities Per Mile
7	**30**	6.1	10.3	13.4	3.9	5.0	5.9	6.1	1.1	1.1	36.6	40.4	43.3	47.2	0.4	0.6
12	**32**	6.3	8.8	16.0	4.6	8.9	6.8	12.0	1.4	2.3	27.6	48.7	35.8	63.0	0.0	0.0
14	**34**	6.2	7.6	18.5	1.6	3.6	4.6	10.6	1.7	3.9	22.9	54.1	29.3	68.7	0.1	0.1
12	**36**	6.3	10.0	19.5	2.5	4.9	6.2	11.6	2.4	3.9	42.6	92.0	51.2	107.5	0.0	0.0
10	**38**	6.2	11.0	18.5	4.1	5.9	18.6	28.4	5.3	8.2	78.6	115.4	102.5	152.0	0.2	0.5
10	**40**	6.1	10.7	17.6	5.7	11.0	12.9	19.8	4.2	5.7	54.3	97.8	71.4	123.2	0.2	0.3
4	**42**	2.9	12.5	16.8	1.5	2.2	4.0	7.0	0.8	1.1	36.8	53.2	41.5	61.3	0.3	0.5
69 Streets		**40.1**														

Fig. 1. **ONE-WAY STREETS - SINGLE FAMILY/LOW-RISE RESIDENTIAL**

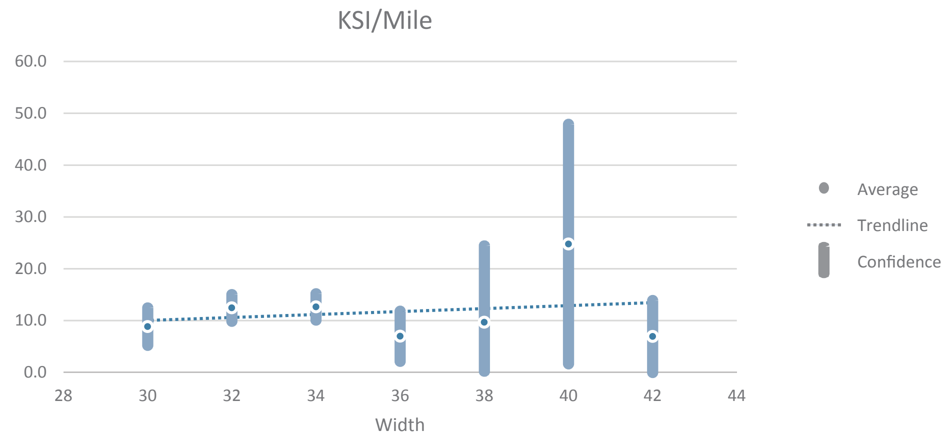
Averages tables and Confidence Charts

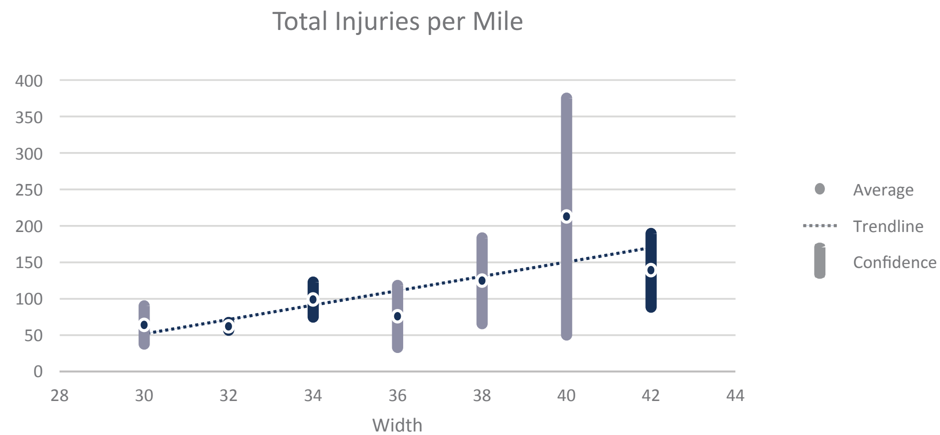






Data Source:
NYCDOT Database
Injury data: NYSDOT/NYSDMV Accident Database
Fatality data: NYCDOT/NYPD Reconciled Fatality Database

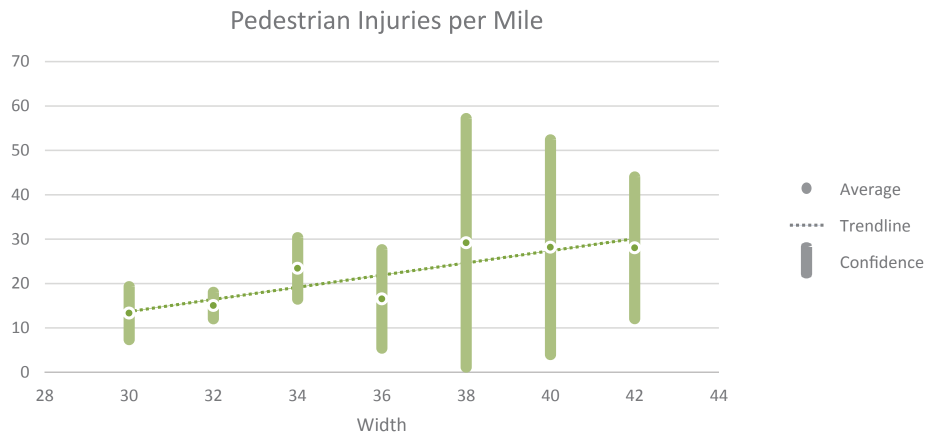


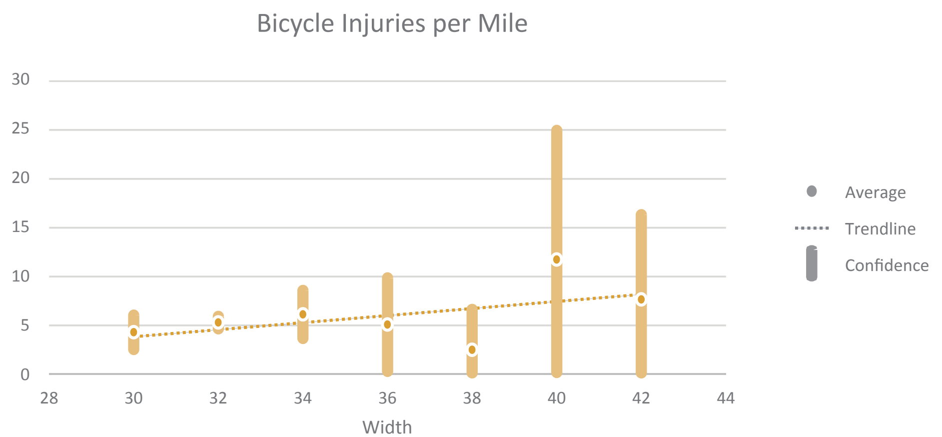


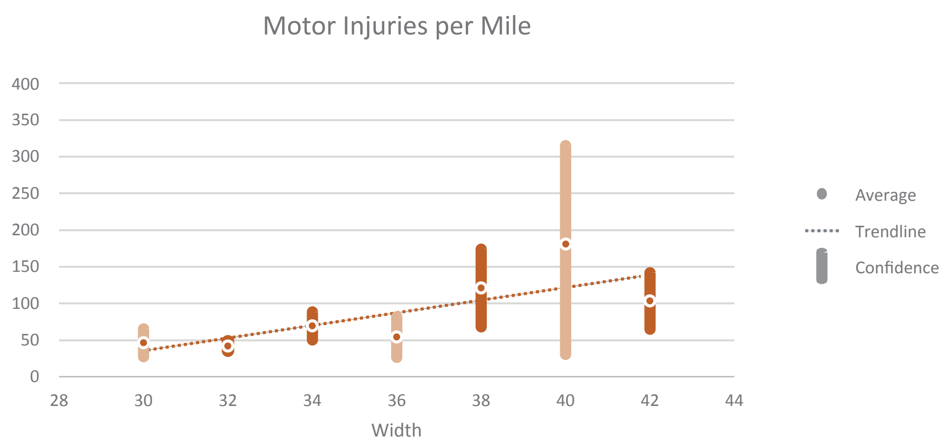
One Way Street with Parallel Parking on both sides in Mid-Rise Residential and Commercial Areas																
	Avg. Width	Total Route Length	Average# of Inter.	Inter. per mile	Total KSI	Avg. KSI /mile	Total Ped Injury	Avg. Ped Injuries Per Mile	Total Bike Injury	Avg. Bike Injuries Per Mile	Total Motor Injury	Avg. Motor Injuries Per Mile	Total Injuries	Average Injuries Per Mile	Fatalities	Fatalities Per Mile
5	**30**	6.1	12.0	9.9	10.6	8.8	23.0	13.3	7.0	4.3	76.8	46.4	106.8	64.1	0.4	0.3
5	**32**	6.0	9.8	8.4	14.8	12.4	17.8	15.0	6.4	5.3	49.6	41.8	73.8	62.1	0.0	0.0
7	**34**	5.9	8.9	12.1	11.4	12.6	19.0	23.4	4.6	6.1	60.3	69.4	83.9	98.9	0.1	0.2
6	**36**	5.1	7.5	9.6	8.6	7.0	15.2	16.5	6.0	5.1	51.4	54.2	72.6	75.8	0.4	0.6
3	**38**	1.3	6.7	15.8	4.0	9.7	12.0	29.2	1.0	2.5	53.7	121.0	52.7	124.7	0.0	0.0
5	**40**	2.6	8.2	16.0	13.0	24.8	13.8	28.2	6.2	11.7	69.8	172.8	89.8	212.7	0.4	1.1
5	**42**	2.2	5.0	11.5	3.2	6.9	12.0	28.0	3.4	7.6	47.4	103.3	62.8	139.0	0.2	0.5
36 Streets		**29.2**														

Fig. 2. **ONE-WAY STREETS - MID-RISE RESIDENTIAL/COMMERCIAL**

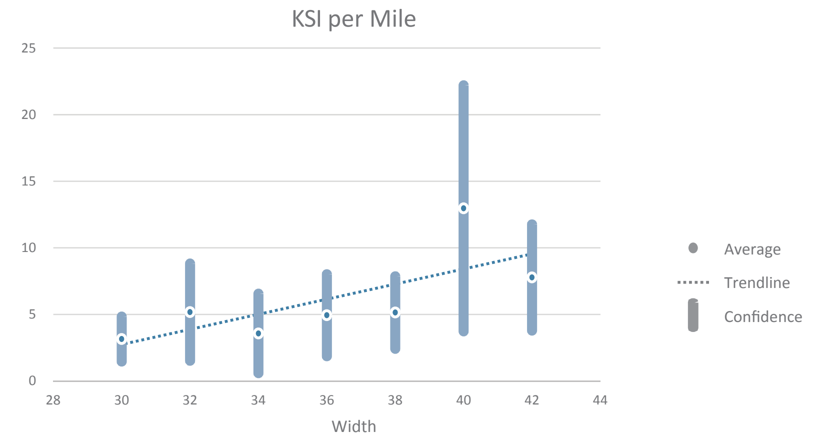
Averages tables and Confidence Charts

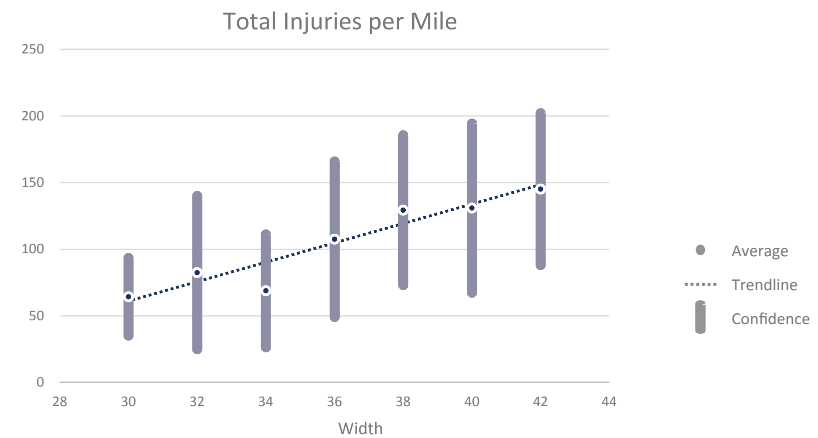






Data Source:
NYCDOT Database
Injury data: NYSDOT/NYSDMV Accident Database
Fatality data: NYCDOT/NYPD Reconciled Fatality Database

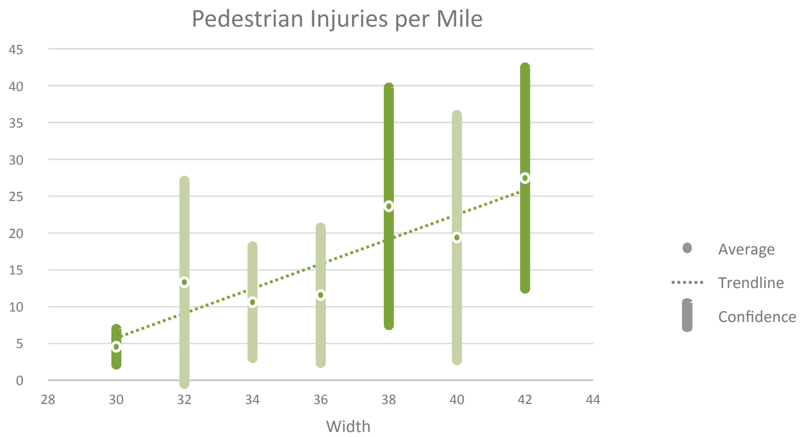


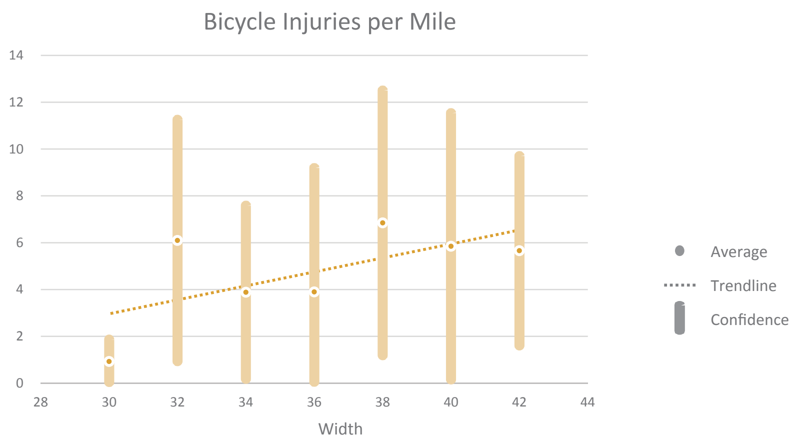


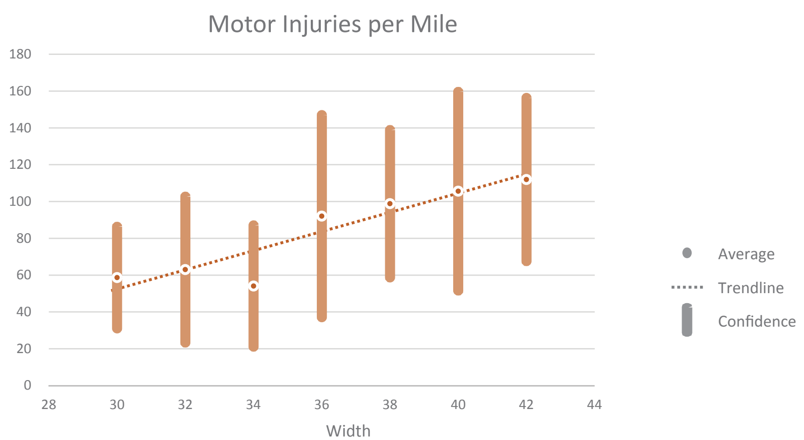
Two Way Streets (One lane in each direction) with Parallel Parking on both sides in Single Family/Low Rise Residential Areas																
Sample Size	Width	Miles	Avg. # of Inter.	Inter. per mile	Avg. KSI	Avg. KSI /mile	Avg. Ped Injury	Avg. Ped Injuries Per Mile	Avg. Bike Injury	Avg. Bike Injuries Per Mile	Avg. Motor Injury	Avg. Motor Injuries Per Mile	Avg. Total Injuries	Avg. Injuries Per Mile	Avg. Fatalities	Fatalities Per Mile
15	**30**	7.3	8.1	16.4	1.7	3.2	2.5	4.6	0.5	1.0	31.1	58.7	34.1	64.3	0.1	0.1
14	**32**	6.1	6.1	15.2	2.1	5.2	4.9	13.3	2.5	6.1	25.9	63.0	33.4	82.4	0.0	0.0
14	**34**	6.2	7.6	18.5	1.6	3.6	4.6	10.6	1.7	3.9	22.9	54.1	29.3	68.7	0.1	0.1
12	**36**	6.3	10.0	19.5	2.5	4.9	6.2	11.6	2.4	3.9	42.6	92.0	51.2	107.5	0.0	0.0
12	**38**	7.1	10.4	17.9	3.5	5.1	15.5	23.6	4.4	6.8	67.0	98.8	86.9	129.3	0.2	0.4
12	**40**	6.7	9.6	17.2	6.3	13.0	11.8	19.4	4.3	5.8	55.4	105.6	71.6	130.8	0.3	0.7
10	**42**	6.5	11.1	16.4	4.7	7.8	17.0	27.5	3.3	5.7	69.9	111.9	90.2	145.1	0.4	0.7
89 Streets		**46.2**														

Fig. 3. **TWO-WAY STREETS - SINGLE-FAMILY/LOW-RISE RESIDENTIAL**

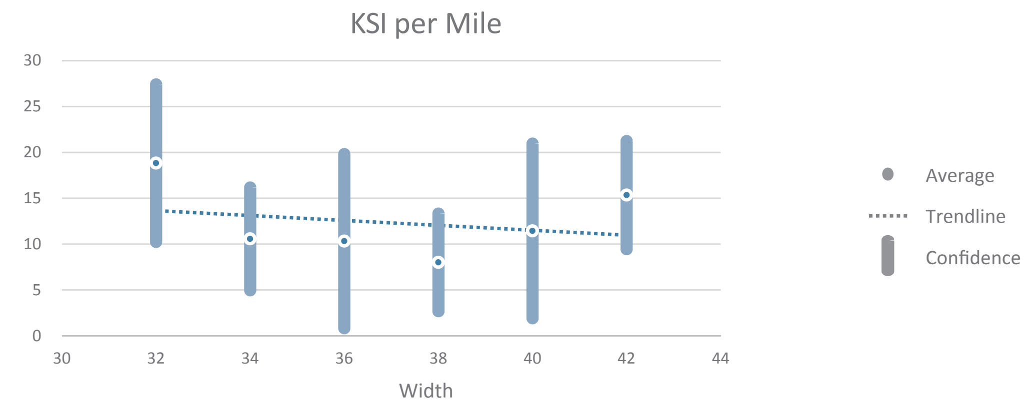
Averages tables and Confidence Charts

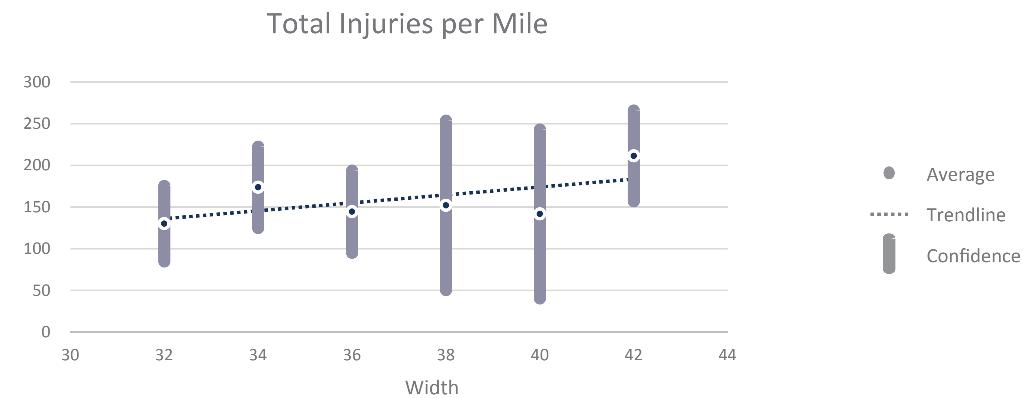






Data Source:
NYCDOT Database
Injury data: NYSDOT/NYSDMV Accident Database
Fatality data: NYCDOT/NYPD Reconciled Fatality Database

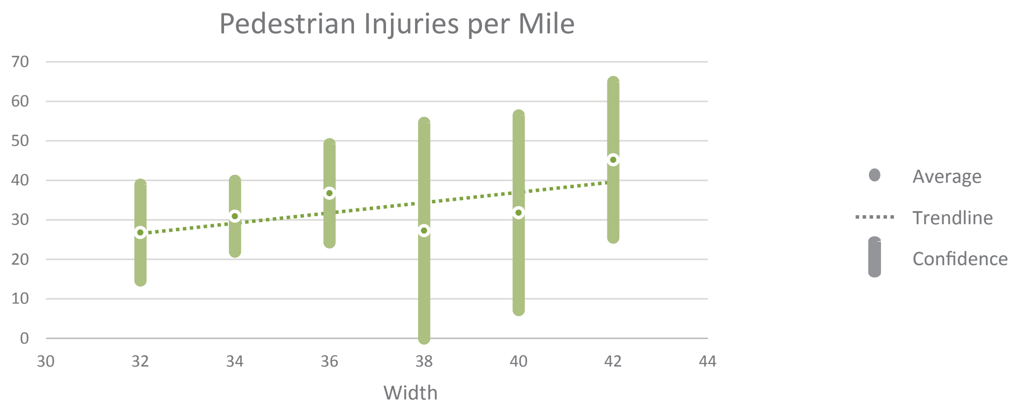


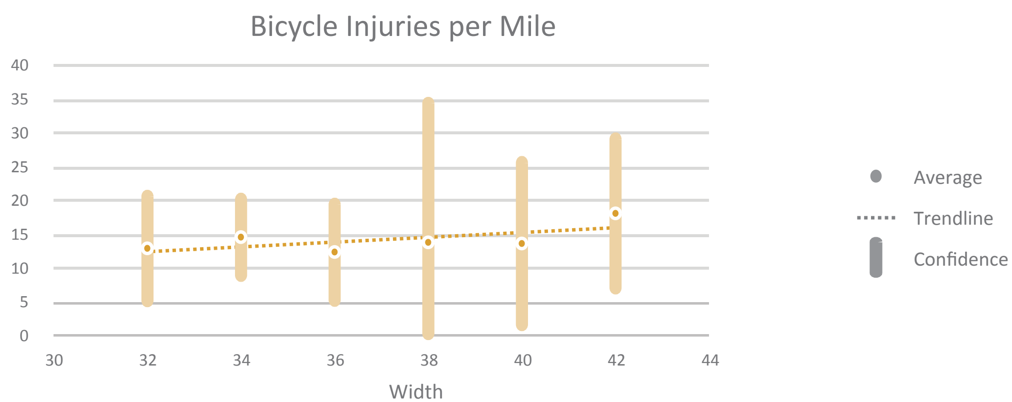


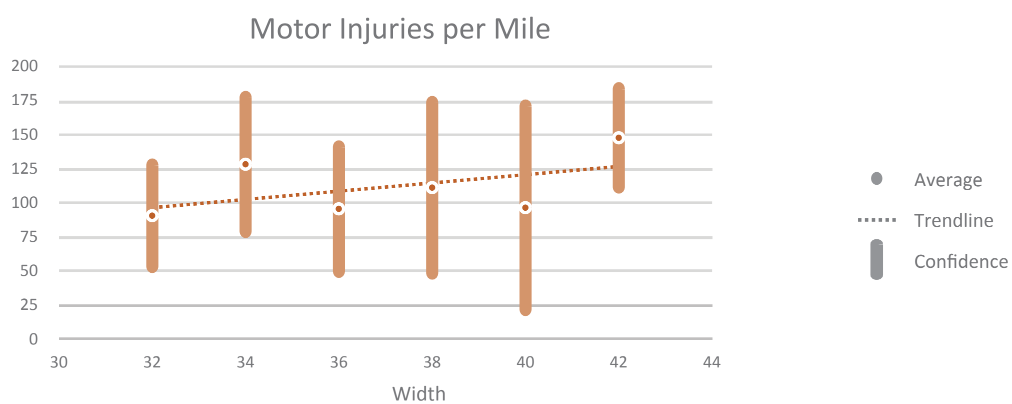
Two-Way Streets (One lane each direction) with Parallel Parking on both sides in Mid-Rise Residential and Commercial Areas																
Sample Size	**Width**	**Miles**	**Avg. # of Inter.**	**Inter. per mile**	**Avg. KSI**	**Avg. KSI /mile**	**Avg. Ped Injury**	**Avg. Ped Injuries Per Mile**	**Avg. Bike Injury**	**Avg. Bike Injuries Per Mile**	**Avg. Motor Injury**	**Avg. Motor Injuries Per Mile**	**Avg. Total Injuries**	**Avg. Injuries Per Mile**	**Avg. Fatalities**	**Fatalities Per Mile**
7	**32**	4.1	11.1	19.2	10.3	18.8	16.9	26.8	9.4	12.9	64.6	90.4	90.9	130.0	1.0	1.1
7	**34**	4.1	10.6	20.1	6.4	10.6	18.9	30.9	8.4	14.5	72.3	128.2	99.6	173.6	0.4	0.8
7	**36**	4.1	10.7	19.3	5.6	10.3	22.9	36.7	7.3	12.3	52.7	95.3	82.9	144.4	0.0	0.0
7	**38**	3.9	12.8	18.9	5.5	8.0	14.8	27.3	6.5	13.8	70.2	111.0	91.5	152.0	0.2	0.3
6	**40**	4.1	13.0	19.0	7.7	11.4	21.3	31.8	9.0	13.6	59.0	96.3	89.3	141.7	0.7	1.0
6	**42**	4.1	8.7	12.7	11.7	15.3	33.2	45.2	14.3	18.1	108.8	147.6	156.8	211.3	0.3	0.5
40 Streets																

Fig. 4. **TWO-WAY STREETS - MID-RISE RESIDENTIAL/COMMERCIAL**

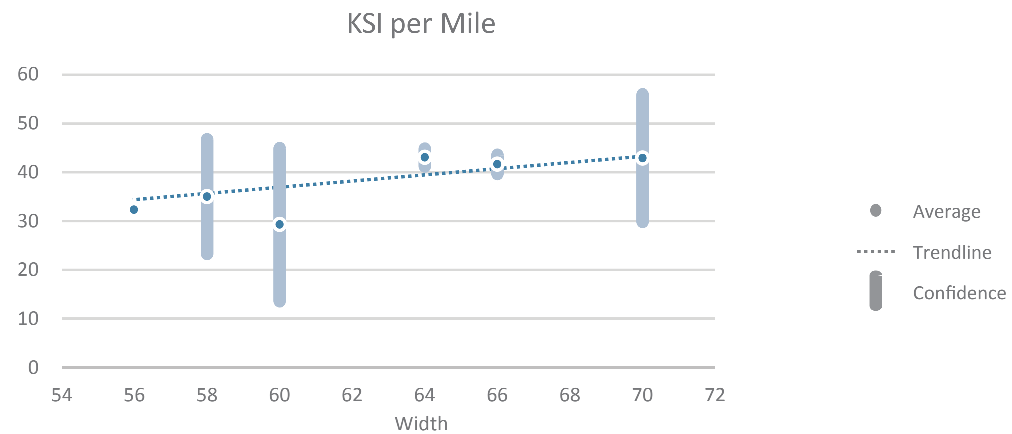
Averages tables and Confidence Charts

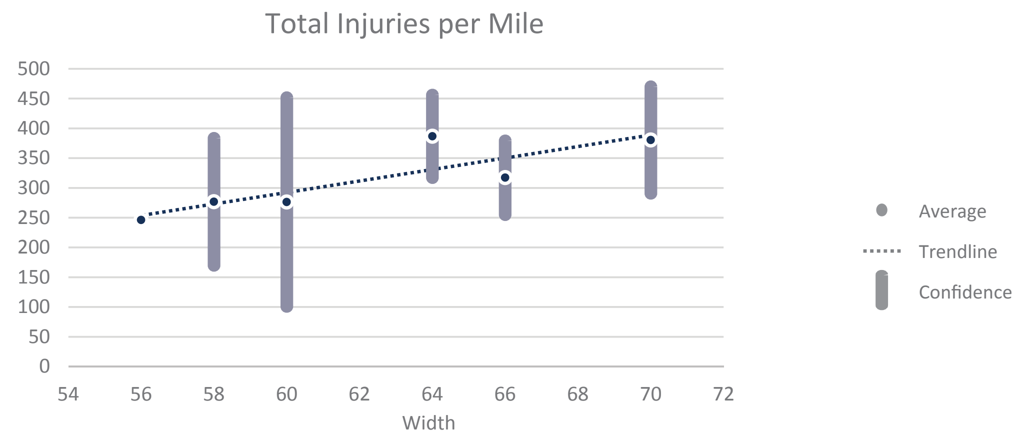






Data Source:
NYCDOT Database
Injury data: NYSDOT/NYSDMV Accident Database
Fatality data: NYCDOT/NYPD Reconciled Fatality Database

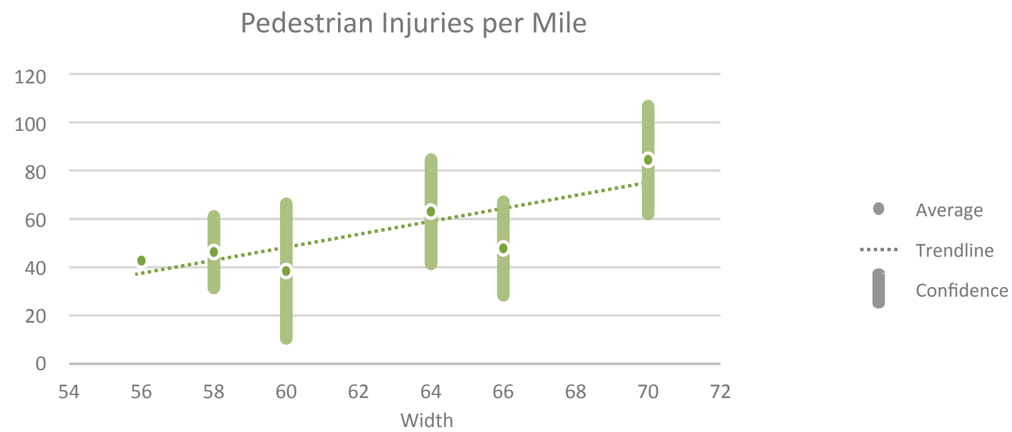


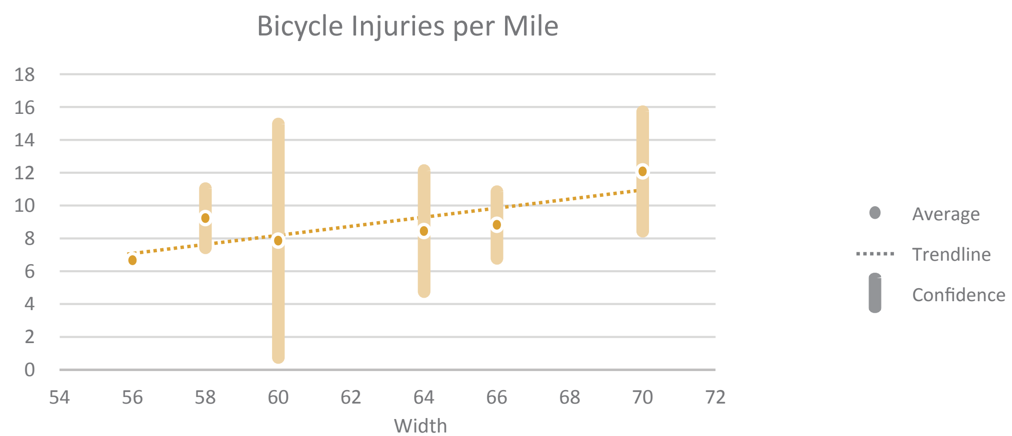


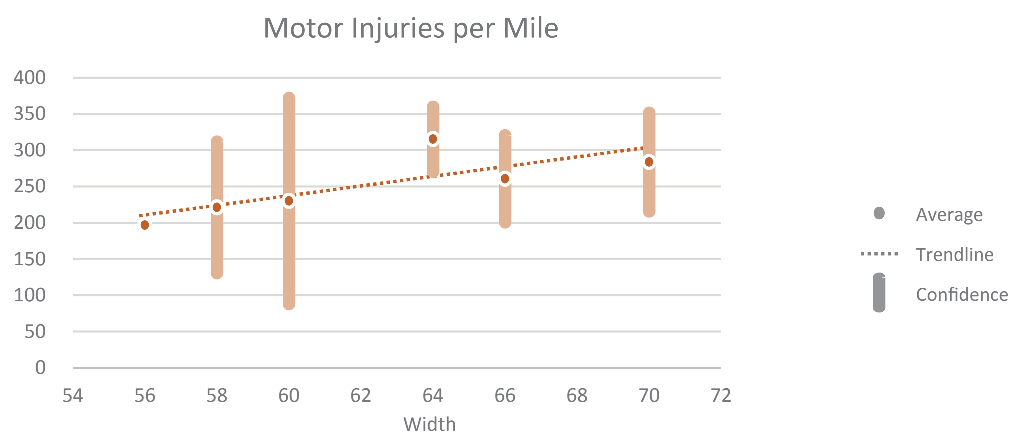
Two Way Streets (Two lanes in each direction) with Parallel Parking on both sides																	
Sample Size	Width	Miles	Avg. # of Inter.	Inter. per mile	Avg. KSI	Avg. KSI /mile	Avg. Ped Injury	Avg. Ped Injuries Per Mile	Avg. Bike Injury	Avg. Bike Injuries Per Mile	Avg. Motor Injury	Avg. Motor Injuries Per Mile	Avg. Total Injuries	Avg. Injuries Per Mile	Avg. Fatalities	Fatalities Per Mile
1	**56**	1.5	16.0	10.7	58.0	38.7	64.0	42.7	10.0	6.7	295.0	196.7	369.0	246.0	1.0	0.7
2	**58**	1.7	11.5	13.2	27.5	35.0	36.5	46.3	7.5	9.2	170.5	221.2	214.5	276.6	0.5	0.4
11	**60**	4.7	14.8	13.2	35.5	29.3	49.3	38.4	10.3	7.9	291.3	230.0	350.8	276.2	3.0	2.4
2	**64**	3.1	21.0	13.0	66.5	43.0	100.0	63.0	13.5	8.4	493.5	315.2	607.0	386.6	2.0	1.4
3	**66**	4.5	24.7	15.7	63.0	41.6	81.0	47.7	14.0	8.8	393.7	260.5	488.7	317.1	1.7	1.3
3	**70**	4.2	21.3	16.1	57.3	42.9	113.0	84.4	17.0	12.1	386.7	283.6	517.0	380.3	1.3	0.8
22 Streets		**19.7**														

Fig. 5. **TWO-WAY STREETS - TWO LANES EACH DIRECTION**

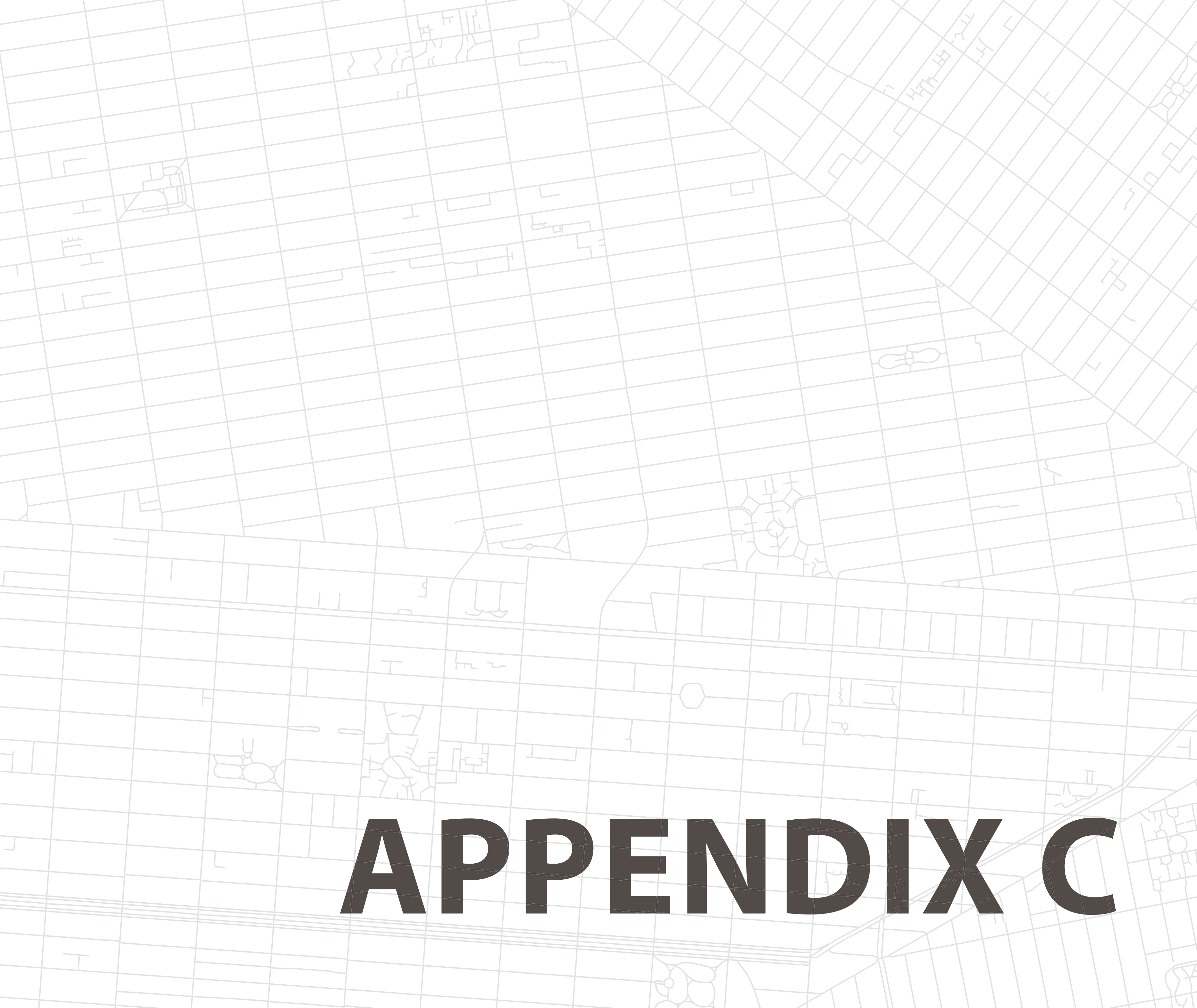
Averages tables and Confidence Charts



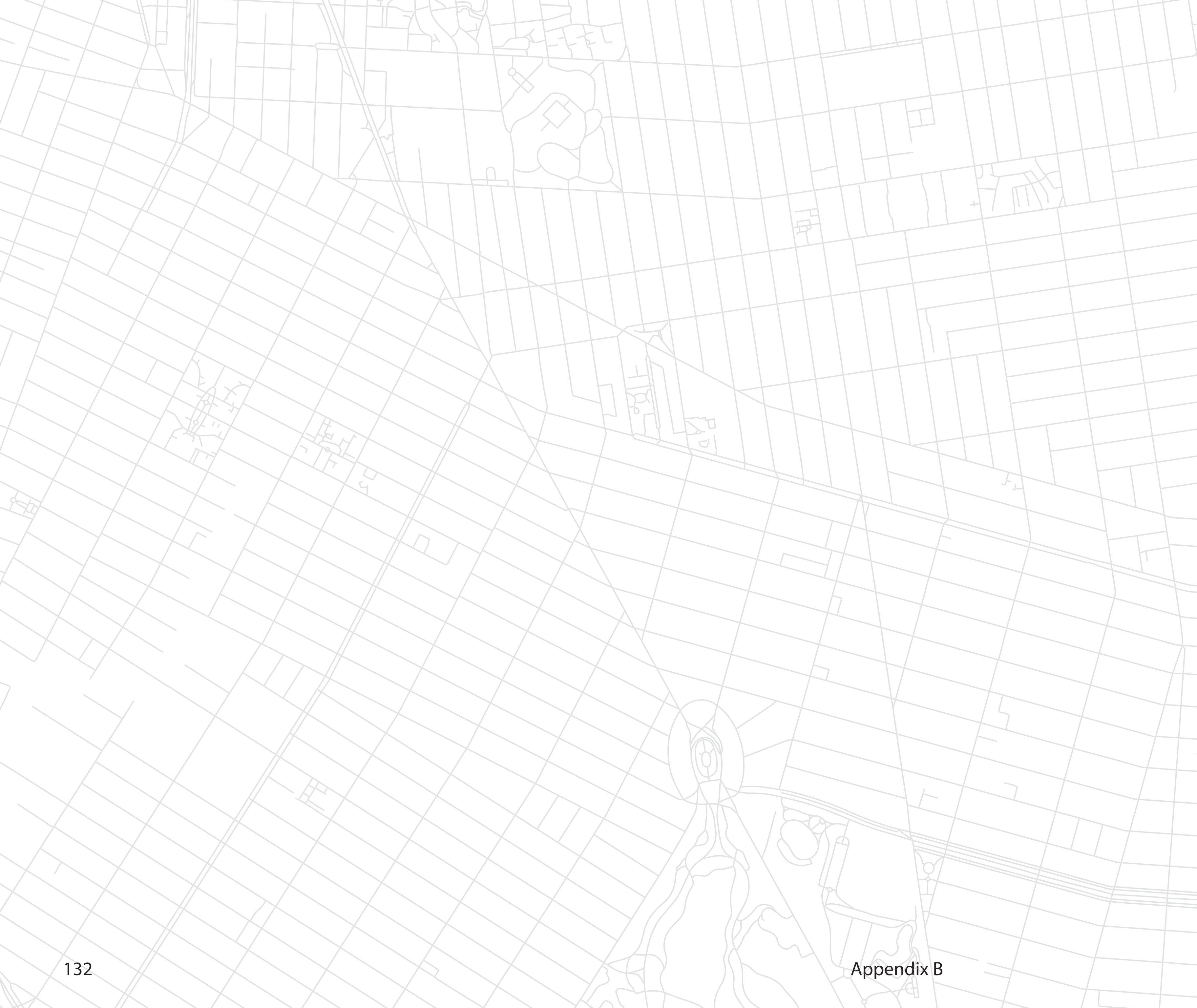




Data Source:
NYCDOT Database
Injury data: NYSDOT/NYSDMV Accident Database
Fatality data: NYCDOT/NYPD Reconciled Fatality Database



APPENDIX C



LEVEL OF SERVICE ANALYSIS

```
              HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                     Inter.:
Agency: Kansas State University         Area Type: All other areas
Date:   2/4/2014                        Jurisd:
Period: AM Existing                     Year  : 2014
Project ID: Bluemont Avenue
E/W St: Bluemont                        N/S St: 11th St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound      |  Westbound      |  Northbound     |  Southbound     |
           | L     T     R   | L     T     R   | L     T     R   | L     T     R   |
           |_________________|_________________|_________________|_________________|
No. Lanes  |   1    2    0   |   1    2    0   |   1    1    0   |   1    1    0   |
LGConfig   | L      TR       | L      TR       | L      TR       | L      TR       |
Volume     |10    321  113   |88    502  11    |201  47    35    |26    33   17    |
Lane Width |12.0 12.0        |12.0 12.0        |12.0 12.0        |12.0 12.0        |
RTOR Vol   |           50    |            5    |            15   |            8    |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_________________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left   A     A
    Thru                A             |     Thru   A     A
    Right               A             |     Right  A     A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left         A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.1   34.4                       10.2  10.3
Yellow           2.0   3.0                        3.0   3.0
All Red          1.0   2.0                        2.0   2.0
                                                   Cycle Length: 80.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane       Adj Sat     Ratios       Lane Group   Approach
Lane    Group      Flow Rate  __________    __________  ___________
Grp     Capacity     (s)      v/c     g/C   Delay LOS    Delay LOS
_______________________________________________________________________________
Eastbound
L         456        1805      0.02   0.56    8.5    A
TR        1514       3521      0.28   0.43    14.9   B     14.7    B

Westbound
L         529        1805      0.19   0.56    8.8    A
TR        1549       3603      0.36   0.43    15.6   B     14.6    B

Northbound
L         408        1805      0.55   0.32    22.9   C
TR        579        1815      0.13   0.32    19.5   B     22.1    C

Southbound
L         173        1347      0.17   0.13    31.5   C
TR        237        1839      0.20   0.13    31.6   C     31.5    C

         Intersection Delay = 17.0  (sec/veh)   Intersection LOS = B
```

Fig. 6. **EXISTING ANALYSIS AT 11TH STREET - AM**

Bluemont and 11th Street

AM Level of Service

HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell
Agency: Kansas State University
Date: 2/4/2014
Period: PM Existing
Project ID: Bluemont Avenue
E/W St: Bluemont

Inter.:
Area Type: All other areas
Jurisd:
Year : 2014
N/S St: 11th St

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	1	2	0	1	2	0	1	1	0	1	1	0
LGConfig	L	TR		L	TR		L	TR		L	TR	
Volume	85	883	204	110	636	23	248	117	113	47	91	50
Lane Width	12.0	12.0		12.0	12.0		12.0	12.0		12.0	12.0	
RTOR Vol			100			15			50			25

Duration 1.00 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4		5	6	7	8
EB Left	A	A			NB Left	A	A		
Thru		A			Thru	A	A		
Right		A			Right	A	A		
Peds					Peds				
WB Left	A	A			SB Left		A		
Thru		A			Thru		A		
Right		A			Right		A		
Peds					Peds				
NB Right					EB Right				
SB Right					WB Right				
Green	7.1	34.4				10.2	10.3		
Yellow	2.0	3.0				3.0	3.0		
All Red	1.0	2.0				2.0	2.0		

Cycle Length: 80.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	388	1805	0.24	0.56	9.7	A		
TR	1528	3553	0.72	0.43	20.5	C	19.6	B
Westbound								
L	258	1805	0.47	0.56	13.7	B		
TR	1549	3603	0.46	0.43	16.4	B	16.0	B
Northbound								
L	389	1805	0.71	0.32	28.3	C		
TR	574	1800	0.35	0.32	21.3	C	25.3	C
Southbound								
L	155	1201	0.34	0.13	33.0	C		
TR	237	1838	0.54	0.13	35.3	D	34.6	C

Intersection Delay = 20.5 (sec/veh) Intersection LOS = C

Fig. 7. **EXISTING ANALYSIS AT 11TH STREET - PM**

Bluemont and 11th Street

PM Level of Service

```
               HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                       Inter.:
Agency: Kansas State University           Area Type: All other areas
Date:   2/4/2014                          Jurisd:
Period: AM Existing                       Year  : 2014
Project ID: Bluemont Avenue Design
E/W St: Bluemont Ave                      N/S St: Juliette St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    2   0   |   1    2   0   |   1    1   0   |   1    1   0   |
LGConfig   | L     TR       | L     TR       | L     TR       | L     TR       |
Volume     |39   426  49    |40   484  25    |80   45   31    |55   51   38    |
Lane Width |12.0 12.0       |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol   |          0     |           15   |          0     |           25   |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
________________________________Signal Operations______________________________
Phase Combination 1     2     3     4 |           5     6     7     8
EB  Left          A     A             | NB  Left   A
    Thru                A             |     Thru   A
    Right               A             |     Right  A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left   A
    Thru                A             |     Thru   A
    Right               A             |     Right  A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.0   51.0                     19.0
Yellow           2.0   3.0                      3.0
All Red          1.0   2.0                      2.0
                                                 Cycle Length: 90.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane       Adj Sat     Ratios       Lane Group   Approach
Lane    Group      Flow Rate  __________    __________  ___________
Grp     Capacity     (s)      v/c    g/C    Delay LOS   Delay LOS
_______________________________________________________________________________
Eastbound
L        579       1805       0.07   0.68   5.2    A
TR       2014      3555       0.26   0.57   10.0-  A     9.6    A

Westbound
L        592       1805       0.07   0.68   5.1    A
TR       2039      3599       0.27   0.57   10.0+  B     9.7    A

Northbound
L        285       1350       0.31   0.21   30.6   C
TR       377       1785       0.22   0.21   29.7   C     30.2   C

Southbound
L        282       1335       0.22   0.21   29.7   C
TR       389       1844       0.18   0.21   29.4   C     29.5   C

         Intersection Delay = 13.9  (sec/veh)   Intersection LOS = B
```

Fig. 8. **EXISTING ANALYSIS AT JULIETTE STREET - AM**

Bluemont and Juliette Street

AM Level of Service

```
                    HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                         Inter.:
Agency: Kansas State University             Area Type: All other areas
Date:   2/4/2014                            Jurisd:
Period: PM Existing                         Year  : 2014
Project ID: Bluemont Avenue Design
E/W St: Bluemont Ave                        N/S St: Juliette St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    2    0  |   1    2    0  |   1    1    0  |   1    1    0  |
LGConfig   | L      TR      | L      TR      | L      TR      | L      TR      |
Volume     |66    751   51  |47    609   59  |94    120   46  |117   128   51  |
Lane Width |12.0 12.0       |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol   |           0    |           15   |          0     |           25   |
_______________________________________________________________________________
Duration     1.00      Area Type: All other areas
______________________________Signal Operations________________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left   A
    Thru                A             |     Thru   A
    Right               A             |     Right  A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left   A
    Thru                A             |     Thru   A
    Right               A             |     Right  A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.0   51.0                     19.0
Yellow           2.0   3.0                      3.0
All Red          1.0   2.0                      2.0
                                                 Cycle Length: 90.0    secs
____________________Intersection Performance Summary___________________________
Appr/    Lane       Adj Sat     Ratios        Lane Group   Approach
Lane     Group      Flow Rate   __________    __________   ___________
Grp      Capacity     (s)       v/c    g/C    Delay LOS    Delay LOS
_______________________________________________________________________________
Eastbound
L         485       1805        0.15   0.68    5.7    A
TR        2026      3575        0.44   0.57    11.4   B     11.0   B

Westbound
L         411       1805        0.13   0.68    6.1    A
TR        2025      3573        0.36   0.57    10.7   B     10.4   B

Northbound
L         227       1074        0.46   0.21    32.5   C
TR        384       1821        0.48   0.21    32.1   C     32.2   C

Southbound
L         216       1021        0.60   0.21    36.8   D
TR        391       1852        0.44   0.21    31.6   C     33.9   C

         Intersection Delay = 16.4  (sec/veh)   Intersection LOS = B
```

Fig. 9. **EXISTING ANALYSIS AT JULIETTE STREET - PM**

Bluemont and Juliette Street

PM Level of Service

```
               HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                       Inter.:
Agency: Kansas State University           Area Type: All other areas
Date:   2/4/2014                          Jurisd:
Period: AM Proposed                       Year  : 2014
Project ID: Bluemont Avenue
E/W St: Bluemont                          N/S St: 11th St

_________________________SIGNALIZED INTERSECTION SUMMARY______________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    1    1  |   1    2    0  |   1    1    0  |   1    1    0  |
LGConfig   | L      T    R  | L     TR       | L     TR       | L     TR       |
Volume     |10   321  113   |88   502  11    |201  47   35    |17   33   47    |
Lane Width |12.0 12.0 12.0  |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol   |          0     |          0     |          0     |          0     |
______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_______________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left   A     A
    Thru                A             |     Thru   A     A
    Right               A             |     Right  A     A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left        A
    Thru                A             |     Thru        A
    Right               A             |     Right       A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            4.0   53.0                       10.0  12.0
Yellow           2.0   3.0                        2.0   3.0
All Red          1.0   2.0                        1.0   2.0
                                                   Cycle Length: 95.0    secs
____________________Intersection Performance Summary__________________________
Appr/   Lane       Adj Sat     Ratios        Lane Group   Approach
Lane    Group      Flow Rate  __________     __________  ___________
Grp     Capacity     (s)      v/c     g/C    Delay LOS   Delay LOS
______________________________________________________________________________
Eastbound
L        493       1805      0.02   0.63    6.9    A
T        1060      1900      0.34   0.56    11.6   B     11.1    B
R        901       1615      0.14   0.56    10.1   B
Westbound
L        576       1805      0.17   0.63    7.6    A
TR       2008      3599      0.28   0.56    11.1   B     10.6    B

Northbound
L        330       1805      0.68   0.26    35.1   D
TR       468       1778      0.19   0.26    27.4   C     32.9    C

Southbound
L        167       1326      0.11   0.13    37.1   D
TR       219       1733      0.41   0.13    39.5   D     39.0    D

         Intersection Delay = 17.1  (sec/veh)   Intersection LOS = B
```

Fig. 10. **PROPOSED ANALYSIS AT 11TH STREET - AM**

Bluemont and 11th Street

AM Level of Service

```
                HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                     Inter.:
Agency: Kansas State University         Area Type: All other areas
Date:   2/4/2014                        Jurisd:
Period: PM Proposed                     Year  : 2014
Project ID: Bluemont Avenue
E/W St: Bluemont                        N/S St: 11th St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    1    1  |   1    2    0  |   1    1    0  |   1    1    0  |
LGConfig   | L      T    R  | L     TR       | L     TR       | L     TR       |
Volume     |85   883  204   |110  636  23    |248  117  113   |47   91   50    |
Lane Width |12.0 12.0 12.0  |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol   |           150  |           20   |          100   |           50   |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_________________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left A     A
    Thru                A             |     Thru A     A
    Right               A             |     Right A    A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left       A
    Thru                A             |     Thru       A
    Right               A             |     Right      A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            3.0   50.0                     11.0  10.0
Yellow           2.0   3.0                      2.0   3.0
All Red          1.0   2.0                      1.0   2.0
                                                 Cycle Length: 90.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane        Adj Sat     Ratios       Lane Group   Approach
Lane    Group       Flow Rate  __________    __________  ___________
Grp     Capacity      (s)      v/c    g/C    Delay LOS   Delay LOS
_______________________________________________________________________________
Eastbound
L        403        1805       0.23   0.62   7.8   A
T        1056       1900       0.93   0.56   35.8  D     32.1   C
R        897        1615       0.07   0.56   9.3   A
Westbound
L        144        1805       0.85   0.62   66.1  E
TR       2004       3608       0.35   0.56   11.2  B     19.2   B

Northbound
L        338        1805       0.82   0.27   46.9  D
TR       499        1872       0.29   0.27   26.5  C     39.9   D

Southbound
L        140        1264       0.37   0.11   38.8  D
TR       211        1900       0.48   0.11   39.3  D     39.1   D

         Intersection Delay = 29.6  (sec/veh)   Intersection LOS = C
```

Fig. 11. **PROPOSED ANALYSIS AT 11TH STREET - PM**

Bluemont and 11th Street PM Level of Service

```
                HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                     Inter.:
Agency: Kansas State University         Area Type: All other areas
Date:   2/4/2014                        Jurisd:
Period: PM Existing                     Year  : 2014
Project ID: Bluemont Avenue Design
E/W St: Bluemont Ave                    N/S St: Juliette St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
              |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
              | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
              |________________|________________|________________|________________|
No. Lanes     |   1    1    0  |   1    1    0  |   1    1    0  |   1    1    0  |
LGConfig      | L      TR      | L      TR      | L      TR      | L      TR      |
Volume        |39   426  49    |40   484  25    |80   45   31    |55   51   38    |
Lane Width    |12.0 12.0       |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol      |           0    |           15   |          0     |           25   |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations________________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left   A     A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left   A     A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.0   47.0                       5.0   15.0
Yellow           2.0   3.0                        2.0   3.0
All Red          1.0   2.0                        1.0   2.0
                                                   Cycle Length: 90.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane       Adj Sat     Ratios       Lane Group   Approach
Lane    Group      Flow Rate   __________   __________   ___________
Grp     Capacity     (s)       v/c    g/C   Delay LOS    Delay LOS
_______________________________________________________________________________
Eastbound
L        442        1805       0.10   0.63    8.4    A
TR       977        1871       0.54   0.52    14.9   B    14.4    B

Westbound
L        458        1805       0.10   0.63    8.1    A
TR       989        1894       0.56   0.52    15.2   B    14.6    B

Northbound
L        295        1805       0.30   0.26    27.0   C
TR       298        1785       0.28   0.17    33.3   C    30.0    C

Southbound
L        293        1805       0.21   0.26    26.3   C
TR       307        1844       0.23   0.17    32.9   C    29.9    C

         Intersection Delay = 17.7  (sec/veh)   Intersection LOS = B
```

Fig. 12. **PROPOSED ANALYSIS AT JULIETTE STREET - AM**

Bluemont and Juliette Street

AM Level of Service

```
                 HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                       Inter.:
Agency: Kansas State University           Area Type: All other areas
Date:   2/4/2014                          Jurisd:
Period: PM Existing                       Year  : 2014
Project ID: Bluemont Avenue Design
E/W St: Bluemont Ave                      N/S St: Juliette St

_________________________SIGNALIZED INTERSECTION SUMMARY________________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    1    0  |   1    1    0  |   1    1    0  |   1    1    0  |
LGConfig   | L     TR       | L     TR       | L     TR       | L     TR       |
Volume     |66   751  51    |47   609  59    |94   120  46    |117  128  51    |
Lane Width |12.0 12.0       |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol   |           0    |           15   |          0     |           25   |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations________________________________
Phase Combination 1     2     3     4 |            5     6     7     8
EB  Left          A     A             | NB  Left   A     A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left   A     A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.0   47.0                       5.0   15.0
Yellow           2.0   3.0                        2.0   3.0
All Red          1.0   2.0                        1.0   2.0
                                                   Cycle Length: 90.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane       Adj Sat     Ratios       Lane Group   Approach
Lane    Group      Flow Rate   __________   __________   ___________
Grp     Capacity     (s)       v/c    g/C   Delay LOS    Delay LOS
_______________________________________________________________________________
Eastbound
L        312        1805       0.23   0.63  11.9   B
TR       983        1882       0.91   0.52  33.5   C     31.9   C

Westbound
L        224        1805       0.23   0.63  17.2   B
TR       982        1881       0.74   0.52  19.8   B     19.6   B

Northbound
L        239        1805       0.44   0.26  28.1   C
TR       304        1821       0.61   0.17  38.2   D     34.6   C

Southbound
L        228        1805       0.57   0.26  32.8   C
TR       309        1852       0.55   0.17  36.6   D     35.0-  C

         Intersection Delay = 28.5  (sec/veh)   Intersection LOS = C
```

Fig. 13. **PROPOSED ANALYSIS AT JULIETTE STREET - PM**

Bluemont and Juliette Street PM Level of Service

```
                HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                       Inter.:
Agency: Kansas State University           Area Type: All other areas
Date:   2/4/2014                          Jurisd:
Period: AM Proposed                       Year  : 2014
Project ID: Bluemont Avenue
E/W St: Bluemont                          N/S St: 11th St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    1    1  |   1    2    0  |   1    1    0  |   1    1    0  |
LGConfig   | L      T    R  | L      TR      | L      TR      | L      TR      |
Volume     |10   432  113  |88   676  11   |201  63   35   |17   44   47   |
Lane Width |12.0 12.0 12.0 |12.0 12.0      |12.0 12.0      |12.0 12.0      |
RTOR Vol   |           0    |           0    |           0    |           0    |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_________________________________
Phase Combination 1     2     3     4 |           5     6     7     8
EB  Left          A     A             | NB  Left  A     A
    Thru                A             |     Thru  A     A
    Right               A             |     Right A     A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left        A
    Thru                A             |     Thru        A
    Right               A             |     Right       A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            4.0   53.0                      10.0  12.0
Yellow           2.0   3.0                       2.0   3.0
All Red          1.0   2.0                       1.0   2.0
                                                  Cycle Length: 95.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane       Adj Sat     Ratios       Lane Group   Approach
Lane    Group      Flow Rate  __________    __________   ___________
Grp     Capacity     (s)      v/c    g/C    Delay LOS    Delay LOS
_______________________________________________________________________________
Eastbound
L        394       1805       0.03   0.63   7.3    A
T        1060      1900       0.45   0.56   12.7   B     12.1    B
R        901       1615       0.14   0.56   10.1   B
Westbound
L        474       1805       0.21   0.63   8.4    A
TR       2009      3601       0.38   0.56   11.9   B     11.5    B

Northbound
L        328       1805       0.68   0.26   35.4   D
TR       473       1798       0.23   0.26   27.7   C     32.8    C

Southbound
L        165       1305       0.12   0.13   37.1   D
TR       221       1753       0.46   0.13   40.0   D     39.5    D

         Intersection Delay = 17.1  (sec/veh)   Intersection LOS = B
```

Fig. 14. **FUTURE ANALYSIS AT 11TH STREET - AM**

Bluemont and 11th Street

AM Level of Service

```
                 HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                        Inter.:
Agency: Kansas State University            Area Type: All other areas
Date:   2/4/2014                           Jurisd:
Period: PM Proposed                        Year  : 2014
Project ID: Bluemont Avenue
E/W St: Bluemont                           N/S St: 11th St

_________________________SIGNALIZED INTERSECTION SUMMARY________________________
           |  Eastbound    |  Westbound    |  Northbound   |  Southbound   |
           | L    T    R   | L    T    R   | L    T    R   | L    T    R   |
           |_______________|_______________|_______________|_______________|
No. Lanes  |   1    1    1 |   1    2    0 |   1    1    0 |   1    1    0 |
LGConfig   | L     T     R | L      TR     | L      TR     | L      TR     |
Volume     |85   1189 204  |110  856  23   |248  157  113  |47   122  50   |
Lane Width |12.0 12.0 12.0 |12.0 12.0      |12.0 12.0      |12.0 12.0      |
RTOR Vol   |          150  |          20   |          100  |          50   |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_________________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left  A     A
    Thru                A             |     Thru        A
    Right               A             |     Right       A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left  A     A
    Thru                A             |     Thru        A
    Right               A             |     Right       A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            4.0   53.0                      10.0  12.0
Yellow           2.0   3.0                       2.0   3.0
All Red          1.0   2.0                       1.0   2.0
                                                  Cycle Length: 95.0    secs
____________________Intersection Performance Summary___________________________
Appr/    Lane       Adj Sat     Ratios       Lane Group   Approach
Lane     Group      Flow Rate  __________    __________  ___________
Grp      Capacity     (s)      v/c     g/C   Delay LOS   Delay LOS
_______________________________________________________________________________
Eastbound
L         315        1805      0.30   0.63   9.0    A
T         1060       1900      1.25   0.56   472.6  F    424.3  F
R         901        1615      0.07   0.56   9.7    A
Westbound
L         156        1805      0.78   0.63   47.8   D
TR        2013       3608      0.47   0.56   12.8   B    16.8   B

Northbound
L         300        1805      0.92   0.26   80.4   F
TR        237        1879      0.79   0.13   59.1   E    71.8   E

Southbound
L         270        1805      0.19   0.26   27.4   C
TR        240        1900      0.57   0.13   42.2   D    38.1   D

         Intersection Delay = 213.6 (sec/veh)   Intersection LOS = F
```

Fig. 15. **FUTURE ANALYSIS AT 11TH STREET - PM**

Bluemont and 11th Street PM Level of Service

```
                HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                       Inter.:
Agency: Kansas State University           Area Type: All other areas
Date:   2/4/2014                          Jurisd:
Period: PM Existing                       Year  : 2014
Project ID: Bluemont Avenue Design
E/W St: Bluemont Ave                      N/S St: Juliette St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound     |  Westbound     |  Northbound    |  Southbound    |
           | L    T    R    | L    T    R    | L    T    R    | L    T    R    |
           |________________|________________|________________|________________|
No. Lanes  |   1    1    0  |   1    1    0  |   1    1    0  |   1    1    0  |
LGConfig   | L      TR      | L      TR      | L      TR      | L      TR      |
Volume     |39   573   49   |40   651   25   |80   61    31   |55   69    38   |
Lane Width |12.0 12.0       |12.0 12.0       |12.0 12.0       |12.0 12.0       |
RTOR Vol   |          0     |          15    |          0     |          25    |
_______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_______________________________
Phase Combination 1     2     3     4 |          5     6     7     8
EB  Left          A     A             | NB  Left  A     A
    Thru                A             |     Thru        A
    Right               A             |     Right       A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left  A     A
    Thru                A             |     Thru        A
    Right               A             |     Right       A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.0   47.0                    5.0   15.0
Yellow           2.0   3.0                     2.0   3.0
All Red          1.0   2.0                     1.0   2.0
                                                Cycle Length: 90.0    secs
____________________Intersection Performance Summary___________________________
Appr/   Lane       Adj Sat     Ratios       Lane Group   Approach
Lane    Group      Flow Rate   __________   __________   ___________
Grp     Capacity     (s)       v/c    g/C   Delay LOS    Delay LOS
_______________________________________________________________________________
Eastbound
L         306        1805      0.14   0.63   11.6   B
TR        981        1878      0.70   0.52   18.6   B     18.2    B

Westbound
L         337        1805      0.13   0.63   10.6   B
TR        990        1896      0.74   0.52   19.9   B     19.3    B

Northbound
L         292        1805      0.30   0.26   27.0   C
TR        301        1805      0.34   0.17   33.8   C     30.6    C

Southbound
L         290        1805      0.21   0.26   26.3   C
TR        309        1856      0.29   0.17   33.4   C     30.6    C

         Intersection Delay = 21.0  (sec/veh)   Intersection LOS = C
```

Fig. 16. **FUTURE ANALYSIS AT JULIETTE STREET - AM**

Bluemont and Juliette Street

AM Level of Service

```
                 HCS2000: Signalized Intersections Release 4.1d

Analyst: C. Gorrell                       Inter.:
Agency: Kansas State University           Area Type: All other areas
Date:   2/4/2014                          Jurisd:
Period: PM Existing                       Year  : 2014
Project ID: Bluemont Avenue Design
E/W St: Bluemont Ave                      N/S St: Juliette St

_________________________SIGNALIZED INTERSECTION SUMMARY_______________________
           |  Eastbound      |  Westbound      |  Northbound     |  Southbound     |
           | L     T     R   | L     T     R   | L     T     R   | L     T     R   |
           |_________________|_________________|_________________|_________________|
No. Lanes  |   1    1    0   |   1    1    0   |   1    1    0   |   1    1    0   |
LGConfig   | L      TR       | L      TR       | L      TR       | L      TR       |
Volume     |66    1011 51    |47    820  59    |94    162  46    |117   172  51    |
Lane Width |12.0 12.0        |12.0 12.0        |12.0 12.0        |12.0 12.0        |
RTOR Vol   |           0     |            15   |            0    |             25  |
______________________________________________________________________________
Duration    1.00      Area Type: All other areas
______________________________Signal Operations_________________________________
Phase Combination 1     2     3     4 |            5     6     7     8
EB  Left          A     A             | NB  Left   A     A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
WB  Left          A     A             | SB  Left   A     A
    Thru                A             |     Thru         A
    Right               A             |     Right        A
    Peds                              |     Peds
NB  Right                             | EB  Right
SB  Right                             | WB  Right
Green            7.0   47.0                       5.0   15.0
Yellow           2.0   3.0                        2.0   3.0
All Red          1.0   2.0                        1.0   2.0
                                                   Cycle Length: 90.0    secs
____________________Intersection Performance Summary__________________________
Appr/   Lane       Adj Sat     Ratios        Lane Group   Approach
Lane    Group      Flow Rate   __________    __________   ___________
Grp     Capacity     (s)       v/c    g/C    Delay LOS    Delay LOS
______________________________________________________________________________
Eastbound
L         224       1805       0.33   0.63   19.4   B
TR        985       1886       1.20   0.52   388.6  F     367.1  F

Westbound
L         224       1805       0.23   0.63   18.9   B
TR        984       1885       0.98   0.52   58.8   E     56.7   E

Northbound
L         199       1805       0.52   0.26   29.6   C
TR        306       1837       0.75   0.17   46.7   D     41.4   D

Southbound
L         190       1805       0.68   0.26   40.6   D
TR        310       1862       0.71   0.17   43.1   D     42.2   D

         Intersection Delay = 185.1 (sec/veh)   Intersection LOS = F
```

Fig. 17. **FUTURE ANALYSIS AT JULIETTE STREET - PM**

Bluemont and Juliette Street PM Level of Service